Macomb County Site Evaluation Tool
User's Manual and Guidance

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1 Overview

This document provides directions and guidance for using the Macomb County Site Evaluation Tool (SET). The Site Evaluation Tool is a Microsoft Excel spreadsheet, and is designed to aid in the assessment of development plans and Best Management Practices (BMPs) to achieve water quality objectives. The BMPs incorporated within the model address the most important current and future water quality issues that development can potentially influence. In addition, the Macomb County SET calculates the site's Water Quality Volume (WQ_v) and Channel Protection Volume (CP_v), two of the Stormwater Criteria which a development site is required to meet under design standards adopted by Macomb County in 2008. The SET also provides a means to easily calculate the benefit of Stormwater Credits for reducing the required WQ_v and CP_v treatment volume. The Stormwater Criteria and Stormwater Credits are discussed in detail in Macomb County's *Procedures and Design Standards for Stormwater Management* [1].

The SET is a useful resource for many in the development community. Developers can use it as a screening tool for testing various site configurations to find ways of helping a site achieve water quality goals and reduce pollutant loads in a cost-effective manner, through the judicious use of both structural BMPs and Stormwater Credits. A completed SET can be submitted with a site plan as part of a development approval process. Municipal staff can use the tool to demonstrate compliance with water quality regulations. A community interested in pursuing a 319 grant for funding assistance for an innovative site design could use the SET to demonstrate pollutant removal benefits. Other practitioners may find it useful as an educational tool for providing a better understanding of the water quality impacts of development and the benefits of BMPs.

The purpose of this document is to provide training and guidance for effectively using the tool. It should be reviewed in its entirety before attempting to use the model. The manual provides the context for understanding the inputs and what they represent, and provides many pointers for using the SET. A Model Documentation report[2] is also available for this tool. The Model Documentation report discusses the underlying models and methodologies used by the SET, and provides the assumptions and data sources used to represent the effectiveness of the BMPs.

This document covers the following:

- Introduction
- Information needed before beginning work
- Helpful notes on navigation and data entry
- Detailed instructions on data input
- Discussion of resulting output
- Examples for using the SET more effectively
- Detailed site example

[1] Macomb County, Michigan. 2008. Procedures and Design Standards for Stormwater Management. Effective August 1, 2008. Macomb County Public Works Office.

[2] Tetra Tech. 2010. Macomb County Site Evaluation Tool Model Documentation. Prepared for Macomb County Public Works Office, Clinton Township, MI.

2 Introduction

The SET addresses two separate, but interrelated functions – calculation of pollutant loading resulting from development, and assessment of Macomb County stormwater criteria for reducing development impacts from pollutant loads and changes in storm event hydrology. The SET provides a unified environment for assessing both of these functions, but they can be evaluated separately in the SET as well. The documentation specifies which items are needed for the Pollutant Load Calculations and which items are needed for the Stormwater Criteria and Credits. Red text and initial capital letters is used to draw attention when these are specified.

Nutrient loading, upland sediment loading[3], elevated bacteria concentrations, and stream channel erosion have been identified as some of the critical water quality issues in Macomb County. Development generally results in an increase in nutrient, bacteria, and upland sediment loading, and changes in site runoff during storms often leads to streambank and channel erosion downstream. However, the changes may be minor or there could be an improvement. For instance, conversion of a site previously used for row crops is likely to decrease upland sediment loading. The SET provides an objective way to evaluate impacts on water quality.

The Macomb County SET calculates the following sources of potential water quality impacts, and the following stormwater criteria required by Macomb County:

- **Annual pollutant loading** for:
  - **Sediment**, which can be deposited in channels, contributes to turbidity, and is one of the leading causes of impacts to aquatic life in streams.
  - **Nutrients** (total phosphorus and total nitrogen), which are especially problematic in reservoirs, larger rivers, and lakes. Excess nutrients drive a cycle that allows algae to bloom and flourish; the algae die off and decay, and the decay leads to oxygen depletion.
  - ***Escherichia coli* (*E. coli*) bacteria**. When *E. coli* concentrations are high, it is more likely that disease-causing microorganisms are present, so *E. coli* is an indicator of risk of contracting disease following contact with waterbodies.
  - **Copper**, one of several metals that is toxic to aquatic life when present in elevated concentrations.
- **Total Suspended Sediment (TSS) Concentration** for meeting the water quality requirement that a site has a maximum discharge concentration of 80 mg/L.
- **Stormwater Criteria** for storm event runoff volume control required by Macomb County for reducing the risk of negative impacts of uncontrolled runoff. The Water Quality Criteria provide a way to ensure BMP treatment capacity is sufficient to remove a significant fraction of pollutant loads generated on an annual basis. The Channel Protection Criteria address runoff from storm events with a return interval of less than 10 years. While 1-year and 2-year storms are not often considered for flood protection, these intermediate large storms represent a higher risk for downstream channel erosion. Very large storms (e.g., 10-year, 25-year) are highly erosive, but do not occur as often as the 1- and 2-year events.

For annual pollutant loading, the SET calculates *surface loads* only, those generated by direct washoff of runoff resulting from rainfall. This includes not only large, intense storms, but also the day-to-day smaller soaking rains that may not cause floods, but do carry pollutants to streams. Loads from

[3] Upland sediment loading is the amount of soil that washes off land areas into streams. Streambank and channel erosion are a separate source of sediment.

groundwater are not included in the SET. Groundwater loads may be a significant source of some pollutants (especially nitrogen), and may be a significant part of a site's total load. However, groundwater sources may be highly variable, depending on local soil conditions, aging sewer infrastructure, failing septic systems, and other factors. Due to the variability of groundwater sources, the SET has been designed to focus on impacts resulting from stormwater runoff, and the management practices that can help mitigate those impacts.

Loads and loading rates in the SET are based on Event Mean Concentrations reported by the Rouge River National Wet Weather Demonstration Project[4] and developed for the Clinton River Watershed HSPF Model[5]. The HSPF Model was calibrated to local water quality data and provides a tool to understand water quality impacts at a larger stream and river watershed scale; the SET provides a way to bring the assessment to a site scale.

BMPs use a variety of techniques to reduce the impact of the increased runoff and pollutant loadings, including reduction in flow velocity and quantity, runoff control, biological uptake, and filtration. The SET has a menu of the most common BMPs used for water quality benefits, as well as some less common ones. The terminology and pollutant removal efficiencies are taken from a number of information sources, some local to Michigan, and some from national databases. **BMPs are assumed to be sized properly for areas draining to them, installed with a high degree of oversight to minimize construction errors, and maintained on a regular basis for continued performance.** Section 5 provides more information about each of the structural and non-structural BMPs in the Macomb County SET.

The SET also calculates key stormwater management criteria required by Macomb County for protection of water resources and for meeting National Pollutant Discharge Elimination System (NPDES) Phase II stormwater regulations. The County has provided a set of unified BMP sizing criteria, which use a tiered approach for the protection of water resources. The criteria include

- Water Quality, designed to protect and improve water quality
- Channel Protection, designed to reduce risk of downstream channel erosion
- Overbank Flood Protection, for reducing impacts of flooding
- Extreme Flood Conveyance to provide passage of very large storm events without damaging site stormwater infrastructure

The County's *Procedures and Design Standards for Stormwater Management* manual (called the "Procedures and Design Standards Manual" in the remainder of this document) contains extensive design guidance which encourages innovative stormwater management that detains, infiltrates, and/or treats stormwater at its source. The Procedures and Design Standards Manual includes several Stormwater Credits that allow for the reduction of the required treatment volume for the first two criteria (called the Water Quality Volume or WQv, and the Channel Protection Volume or CPv). One of the purposes of the SET is to allow for a relatively easy calculation of these volumes and their reductions using Stormwater Credits. The specific implementation of the calculation of the volume criteria and the credits is discussed in detail in this document. The SET also includes an evaluation of compliance with the TSS maximum allowable discharge concentration of 80 mg/L. The SET's calculation of sediment concentration differs somewhat from the one provided in the Manual, but the two methods are fundamentally similar since they are based on the same monitoring data. The user may elect to use either method for evaluation of compliance with the standard.

[4] Cave, K., T. Quasebarth, and E. Harold. 1994. Technical Memorandum: Selection of Stormwater Pollutant Loading Factors. RPO-MOD-TM34.00. Rouge River National Wet Weather Demonstration Project.

[5] Tetra Tech. 2008. Clinton River Watershed HSPF Modeling Calibration and Scenario Report. Prepared for the Clinton River Basin Intercounty Drainage Board.

3 Using the SET

3.1 Before Beginning

Prior to using the model, the following information is needed, most or all of which can be obtained from the preliminary development site plan:

Information needed for both the Pollutant Load Calculations and the Stormwater Criteria and Credits

1. The size (in acres) of the project.
2. The fraction of the project area that is distributed within each of the hydrologic soil groups, A, B, C, or D (refer to NRCS soil survey for hydrological group information).
3. Land use of the project area prior to *and* after implementation of the site plan. Generally, undeveloped land use is a combination of agricultural land uses, forest, and meadow. However, it may reflect an existing development. Post-developed land use includes any changes to the site's land cover resulting from the use of the Stormwater Credits (e.g., impervious surface reduction, protection of forested areas). Available land uses are broken down as follows (input in square feet):

   Pervious Areas:

   a. Agriculture – Areas receiving intensive management for the production of row crops. This category includes vegetable gardens.
   b. Pasture (areas with livestock) – This includes hobby farms.
   c. Wetlands – Areas with frequent or permanent water inundation (bogs, marshes, swamps, wooded wetlands).
   d. Grassland/Meadow/Savannah – Areas with grass/weeds receiving minimal management (for example, no fertilizer, mowed two times or less per year, bushhogged every few years). Abandoned fields with brush/saplings greater than head high should be classified as forest/woods. However, areas with widely spaced trees surrounded by grassland (savannah), including orchards, should be included in the *Grassland/Meadow/Savannah* category.
   e. Forest/Woods – Includes abandoned fields returning to forest (saplings/brush head high at a minimum).
   f. Lawn/Landscaping – All of the pervious developed areas of the site.

   Impervious Areas (Residential, Office, Institutional):

   a. Rooftops (all buildings and canopied areas)
   b. Driveways and/or parking lots (including curb and gutter)
   c. Roads (including curb and gutter)
   d. Sidewalks
   e. Other impervious areas (e.g., tennis courts, patios, and impervious portions of stormwater management BMPs)

Impervious Areas (Commercial & Heavy Industrial):

a. Rooftops (all buildings and canopied areas)

b. Driveways and/or parking lots (including curb and gutter)

c. Roads (including curb and gutter)

d. Sidewalks

e. Other impervious areas (e.g., tennis courts, patios, and impervious portions of stormwater management BMPs)

Stormwater Management and BMP Areas:

a. BMPs with standing water (wet ponds, stormwater wetlands). Any open water (ponds, lakes) at the site should also be placed in this category.

b. Surface area of porous pavement

c. Surface area of green roof (vegetated portion)

d. Pervious BMP areas, such as vegetated basins, swales, bioretention, service areas surrounding wet detention basins, etc. Impervious BMP area should be placed in the *Other Impervious Area* category, if needed.

4. For sites with mixed residential and commercial use, the impervious areas listed above should be broken down appropriately. If the impervious area totals are not yet available, the totals can be estimated. If necessary, the estimated totals can be lumped into rooftop and non-rooftop areas, and the non-rooftop impervious area can be entered in the "Other Impervious Area" category. Note that rooftop areas are treated differently from other impervious surfaces within the SET's internal modeling, so it is important to have a realistic estimate of rooftop area if you are going to lump impervious surfaces.

The following information is needed for the Pollutant Load Calculations. It is also needed for the Stormwater Criteria and Credits if you are NOT using extended detention to meet the WQv.

1. A division of the project area into distinct drainage areas (DAs) that are served by specific stormwater management facilities and/or BMPs. The model allows for up to 10 distinct drainage areas. All of the above land use/land cover areas must be distributed within those drainage areas for the development plan. A drainage area associated with a specific BMP generally includes that BMP and all areas within the project draining to it. Usually a stormwater control or BMP associated with a given drainage area serves the entire drainage area. Where multiple BMPs are specified in series, care must be taken in delineation. It is also possible (and sometimes necessary) to lump like areas together even if they are not connected hydrologically. Further guidance is available in Section 3.9.

2. If you want to include a BMP that is not on the SET list, you may create your own customized BMP. You will need to provide:

   a. Pollutant removal rates for sediment, total nitrogen, total phosphorus, bacteria, and total copper

   b. Expected annual infiltration and evapotranspiration of intercepted storm runoff

Information needed for the Stormwater Criteria and Credits only.

1. Many of the Stormwater Credits encourage the use of alternative site configurations to reduce runoff and improve infiltration, such as decreasing impervious surfaces, and increasing forested and natural areas. Since the WQv and CPv are affected directly by the site's land cover and impervious area, the value of many Stormwater Credits is incorporated directly into the post-development site plan. If you want to better understand the value of Stormwater Credits, you will need to specify the site's post-developed land use *prior to adoption of the Stormwater Credits*. In other words, you will enter the site's post-developed land use for the site that would have been built if the designer was not motivated by the Stormwater Credits. This will be explained in greater detail in Section 3.4.
2. Knowledge of the site's qualifying Stormwater Credits, if used.
3. The site's post-developed land cover, using the land use classes discussed previously, tallied into areas that qualify for specific Stormwater Credits. A given area can qualify for only one Stormwater Credit. If part or all of the site does not qualify for any credits, you will enter that as well.
4. The post-developed site's Time of Concentration (Tc). The SET is not an engineering design tool so it cannot estimate the Tc.
5. Optionally, the Tc for the *Pre-Credit Proposed Land Use* (see Section 3.4).
6. The SET estimates the weighted site Curve Number (CN) for calculation of the WQv. However, you may specify the weighted site Curve Number if you are using values that differ from those assumed within the SET.

3.2 GENERAL NOTES

Note: The Site Evaluation Tool is not compatible with Excel 95 or earlier versions.

Open the SET Microsoft Excel workbook file. You must enable macros to run the SET. If you are prompted to make a choice about macros, select "Enable Macros" (or "Yes," depending on the dialog box you see) to allow macros to run. Excel 2007 will show a bar below the menu ribbons that says "Security Warning Some active content has been disabled," followed by an *Options* button – in that event, click the *Options* button, select *Enable this content*, and click *OK*. You may also need to change your macro security settings; see Appendix A if one of the following occurs:

- When you open the SET, a message appears warning you that macros are disabled. The message includes a lengthy explanation about macro security and available options (newer versions through Excel 2003).
- When you open the SET, you receive no warnings about macro security, but nothing happens when you click on check boxes within the SET.

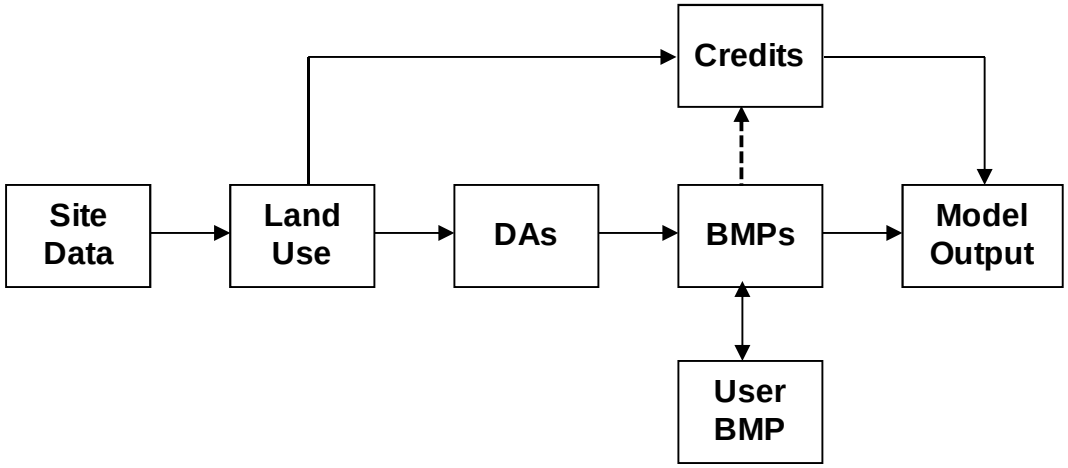
Yellow colored cells denote where user input is required throughout the spreadsheet.

The SET contains several navigation and data entry aids to guide you through the process. For instance, some cells allow only for percent values between 0 and 100 and will display an error message if an invalid number is entered. Other cells show error messages in large red text until data entered in that section sums to a previous value. For example:

Error message: **Unassigned: 125,478**

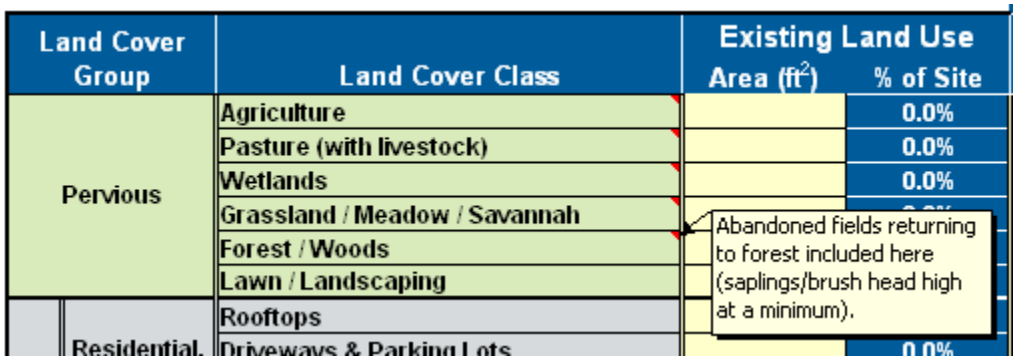
Data entry correct: **Equals Site Area**

There are seven worksheets you will be using in the SET:



The **Site Data**, **Land Use**, **DAs**, **BMPs**, **Credits**, and **User BMP** worksheets are used for data entry. The **Model Output** worksheet is for display of results only. Some of the worksheets are unavailable until you complete data entry on a previous worksheet. For instance, you must enter all of your data on both the **Site Data** and **Land Use** worksheets before you can move to the **DAs** worksheet. However, you can go back to a previous worksheet and make corrections.

The SET makes use of the Excel comments functionality. Comments in Excel show up as red triangles in cell corners. When you place your mouse over the cell, the comment is displayed to the right of the cell in a pop-up box. Comments in the SET provide more information about what the cell means or the cell's function.



3.3 THE *SITE DATA* WORKSHEET

The **Site Data** worksheet allows you to input general information about the site.

The *Project Information* section contains input fields for the following:

- Name of company or organization
- The location of the project
- Scenario name (a way for users to track BMP/site layout scenarios)
- Comment (any notes you want to make)

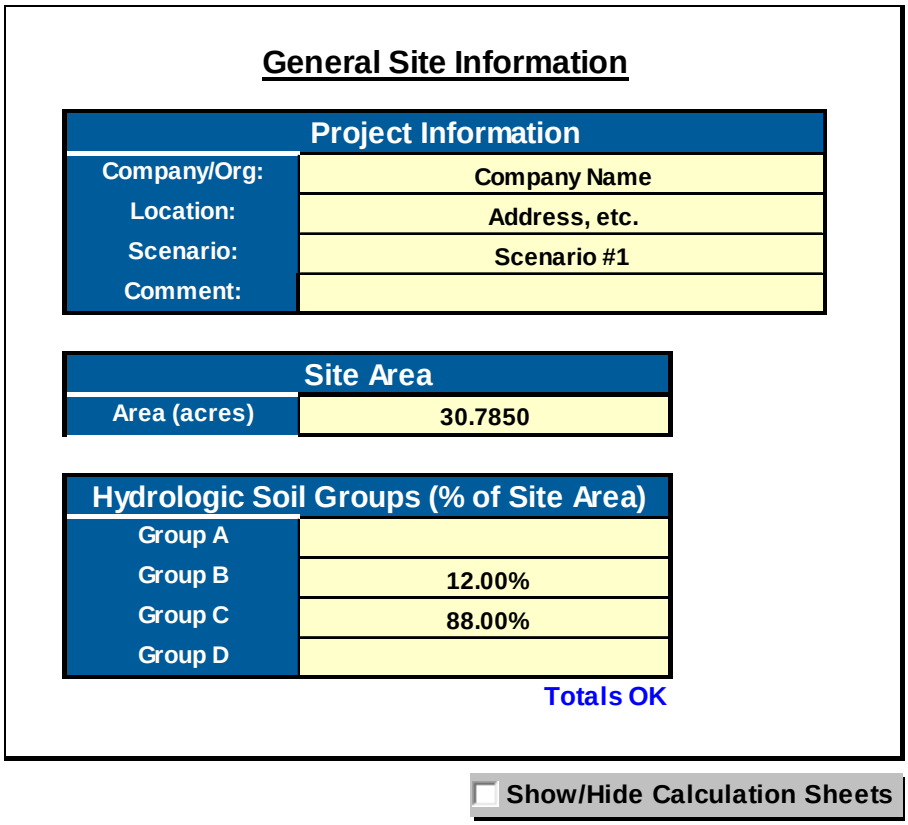
Project Information inputs are optional, but are a useful way of documenting aspects of the project.

Enter the site area (in acres) in the *Site Area* section. You should enter the area to the highest known precision, so you can account for all of the area in subsequent SET entry worksheets, which use square feet.

The *Soil Hydrologic Group* section contains input fields for percent of site area in each soil hydrologic group. The percentages must sum to 100 percent to account for the entire site area. This section is critical for calculating the CPv, so try to obtain the best available information when possible. The Michigan Center for Geographic Information (http://michigan.gov/cgi) provides an extensive library of free GIS data, includes soils data with soil hydrologic group. Be sure to download the detailed county-level data, and not the more general state-level data.

There is also a checkbox to show or hide hidden parameter and calculation worksheets. When the box is checked, several more worksheets appear to the right of the Model Output worksheet. You may view the parameters and calculations if you wish (though you cannot modify them). Most users prefer to leave the box unchecked to simplify navigation within the SET.

When you have completed the required input fields on the **Site Data** worksheet, you may proceed to the **Land Use** worksheet.



General Site Information

Project Information	
Company/Org:	Company Name
Location:	Address, etc.
Scenario:	Scenario #1
Comment:	

Site Area	
Area (acres)	30.7850

Hydrologic Soil Groups (% of Site Area)	
Group A	
Group B	12.00%
Group C	88.00%
Group D	

Totals OK

Show/Hide Calculation Sheets

3.4 THE *LAND USE* WORKSHEET

The **Land Use** worksheet has input fields for the overall site land uses described previously. Land areas are entered in square feet and must sum to the total site area.

There are three sets of columns for entering land use data:

1. *Existing Land Use* – this is the land use of the site prior to incorporation of the proposed site plan. For previously undeveloped sites, the land uses will usually be natural or agricultural. If this is a redevelopment site, you would enter the site's current land use.
2. *Proposed Land Use, Pre-Credit* – the site design prior to adopting changes to land use resulting from using Stormwater Credits. In other words, enter the site's post-developed land use for the site that would have been built if the designer was not motivated by the Stormwater Credits. Entering the *Proposed Land Use, Pre-Credit* land use is optional, and is only useful if you wish to evaluate the benefit of certain Stormwater Credits. When used, the **Model Output** worksheet will display the Pre-Credit WQv and CPv. If you do not wish to enter *Proposed Land Use, Pre-Credit* land use, remove the check from the gray box above the entry columns. The entry cells will become grayed out. Note that the values you use for the *Proposed Land Use, Pre-Credit* land use will not affect the calculation of the final WQv and CPv.
3. *Proposed Land Use, Post-Credit* – the final site design, including stormwater BMPs and incorporation of Stormwater Credits.

You must account for the surface area of structural BMPs, permeable pavement, and green roofs. It is especially important that:

- The area for ponds/wetlands reflects the surface area of the permanent pool only.
- The surface area of permeable pavement reflects only the permeable portion of a driveway/parking lot.
- The surface area of a green roof reflects only the vegetated portion of the green roof.

If the pervious surface area of BMPs is not known, you may enter it under the "Lawn" land use category.

When you have completed the required input fields on the **Land Use** worksheet, you may proceed to the **DAs** worksheet.

***Land Use** Worksheet Example*

The following example illustrates how the design process relates to the three entry columns in the **Land Use** worksheet. A developer planned to develop a 30-acre wooded site into a single-family residential neighborhood with approximately two housing units per acre. The original site plan specified all of the forested land would be cleared, and had a final estimated impervious area of 36.80%. In order to reduce treatment volume requirements for WQv and CPv, the developer decided to reduce impervious area (Credit 1) and preserve forest (Credit 6). The final proposed site plan had a percent impervious area of 32.58%, and about 5.4 acres of forest.

The figure on the following page shows how this data is entered into the **Land Use** worksheet. The site's current (pre-development) land use is entered in the *Existing Land Use* column; in this example, the site is completely forested. Second, the original site plan, prior to application of the Stormwater Credits, is entered in the *Proposed Land Use, Pre-Credit* column. Note there is no forest, and the total percent impervious area is 36.80%. Lastly, the final proposed site plan land use is entered in the *Proposed Land Use, Post-Credit* column, reflecting the reduction in impervious area, and inclusion of forested area.

The *Proposed Land Use, Pre-Credit* land use is somewhat arbitrary – one can imagine any number of starting points. It is simply a tool to allow the designer to explore how changes in site land use influence the WQv and CPv treatment volumes. It has no influence or bearing on the final calculations of the Water Quality Criteria.

To summarize, each of the three entry columns can be described as follows:

- *Existing Land Use* – the site's current land use
- *Proposed Land Use, Pre-Credit*– the site that would have been built prior to changes in land use resulting from adoption of the Stormwater Credits
- *Proposed Land Use, Post-Credit*– the final proposed site plan, including all structural BMPs and incorporation of Stormwater Credits

Land Use Entry

☑ Enter Pre-Credit Proposed Land Use

Land Cover Group	Land Cover Class	Existing Land Use		Proposed Land Use			
				Pre-Credit		Post-Credit	
		Area (ft^2)	% of Site	Area (ft2)	% of Site	Area (ft^2)	% of Site
Pervious	Agriculture		0.0%		0.0%		0.0%
	Pasture (with livestock)		0.0%		0.0%		0.0%
	Wetlands		0.0%		0.0%		0.0%
	Grassland / Meadow / Savannah		0.0%		0.0%		0.0%
	Forest / Woods	1,306,800	100.0%		0.0%	234,000	17.9%
	Lawn / Landscaping		0.0%	825,950	63.2%	647,000	49.5%
Impervious – Residential, Office, Institutional	Rooftops		0.0%	150,000	11.5%	150,000	11.5%
	Driveways & Parking Lots		0.0%	131,250	10.0%	124,000	9.5%
	Other Impervious Area		0.0%		0.0%		0.0%
	Road		0.0%	135,600	10.4%	119,800	9.2%
	Sidewalk		0.0%	64,000	4.9%	32,000	2.4%
Impervious – Commercial & Heavy Industrial	Rooftops		0.0%		0.0%		0.0%
	Parking Lots		0.0%		0.0%		0.0%
	Other Impervious Area		0.0%		0.0%		0.0%
	Road		0.0%		0.0%		0.0%
	Sidewalk		0.0%		0.0%		0.0%
Stormwater Management	Pond/Open Water Surface Area		0.0%		0.0%		0.0%
	Green Roof		0.0%		0.0%		0.0%
	Porous Pavement		0.0%		0.0%		0.0%
	All Other Pervious Structural BMP Area		0.0%		0.0%		0.0%
	Site Totals:	1,306,800	100.0%	1,306,800	100.0%	1,306,800	100.0%
	Check Land Use Totals:	Equals Site Area		Equals Site Area		Equals Site Area	
	Percent Impervious Cover	0.00%		36.80%		32.58%	

3.5 THE *DAS* WORKSHEET

Note: The primary purpose of the DAs worksheet is for evaluating Pollutant Load Calculations. However, you will need to use the DAs worksheet if you are NOT using extended detention to meet the WQv. The DAs and BMPs worksheets are used in concert to calculate the TSS maximum allowable concentration*, which is one of the Water Quality Criteria that must be met when the site does not use extended detention.*

The **DAs** worksheet has input fields for the pervious, impervious, and stormwater management facility land areas, but now you must apportion these by drainage area corresponding to the site's structural BMPs. The worksheet cross-checks that all areas match up properly – that the proportions of each land use match the site totals defined on the **Land Use** worksheet. The worksheet contains an "unassigned" area field that assists you in dividing up the areas and shows the total areas by land use entered in the **Site Data** worksheet (two of ten available drainage areas are shown for clarity). You may also provide brief names of your own for the drainage areas. Section 3.9 provides further guidance about dividing the site into structural BMP drainage areas.

Drainage Areas (DA) associated with BMP sets

Land Cover Group		Land Cover Class	Proposed Site Area (ft2)	Unassinged Area (ft2)	DA1	DA2
Pervious		Agriculture	0	0		
		Pasture (with livestock)	0	0		
		Wetlands	0	0		
		Grassland / Meadow / Savannah	0	0		
		Forest / Woods	234,000	234,000		
		Lawn / Landscaping	612,000	612,000		
Impervious	Residential, Office, Institutional	Rooftops	150,000	150,000		
		Driveways & Parking Lots	124,000	124,000		
		Other Impervious Area	0	0		
		Road	119,800	119,800		
		Sidewalk	32,000	32,000		
	Commercial & Heavy Industrial	Rooftops	0	0		
		Parking Lots	0	0		
		Other Impervious Area	0	0		
		Road	0	0		
		Sidewalk	0	0		
Stormwater Management		Pond/Open Water Surface Area	0	0		
		Green Roof	0	0		
		Porous Pavement	0	0		
		All Other Pervious Structural BMP Area	35,000	35,000		
Total Area			1,306,800	1,306,800		

When you have completed the required input fields on the **DAs** worksheet, you may proceed to the **BMPs** worksheet.

3.6 THE *BMPS* WORKSHEET

The **BMPs** worksheet has input fields for the BMP(s) that serve each drainage area.

The *BMP Assignment for each DA* section allows you to assign a BMP or series of BMPs to each drainage area using check boxes. For instance, in the example shown below, both bioretention and extended dry detention are assigned to drainage area #2, while extended dry detention only is assigned to drainage area #1.

Note that there are no checkboxes for permeable pavement or green roofs – these are automatically selected and enabled by assigning land use area to them on the **DAs** worksheet (see drainage area #3 for an example). Both of these BMPs behave in a fundamentally different way than other BMPs; the entire surface area of permeable pavement or a green roof intercepts and treats runoff, while other BMPs receive runoff from upland land areas. As such, permeable pavement and green roofs are treated as surfaces within the SET.

BMPs	DA1	DA2	DA3
Extended Wet Detention	☐	☐	☐
Extended Dry Detention	☑	☑	☐
Infiltration Basin	☐	☐	☐
Bioretention	☐	☑	☐
Sand Filter	☐	☐	☐
Infiltration Trench	☐	☐	☐
Vegetated Swale	☐	☐	☐
Bioswale	☐	☐	☐
Vegetated Filter Strip	☐	☐	☐
Dry Well	☐	☐	☐
Rain Barrels	☐	☐	☐
Cistern	☐	☐	☐
Hydrodynamic Device	☐	☐	☐
Catch Basin with Sump	☐	☐	☐
User-defined BMP	☐	☐	☐
Green Roof	N/A	N/A	N/A
Porous Pavement	N/A	N/A	Selected

If you specify a "User BMP" (one not included in the menu of BMPs), you must enter pollutant removal efficiencies and other properties within the **User BMP** worksheet. Click the tab at the bottom to reach the **User BMP** worksheet, and enter the requested data. You must also provide a reference to documentation supporting the data you enter.

DA1		
	BMP Name:	
Infiltration	Annual flow converted to infiltration (percent)	
ET*	Annual flow converted to evaporation (percent)	
Removal Efficiencies (as percent)	Total N	
	Total P	
	TSS	
	E coli	
	Copper	

Returning to the **BMPs** worksheet, the combined pollutant removal efficiencies of the BMPs serving each drainage area are shown at the bottom of the worksheet, as well as annual runoff converted to infiltration and/or evapotranspiration.

Net Reductions for each DA	DA1	DA2	DA3
Annual runoff converted to Infiltration + ET	15.0%	50.7%	7.8%
Total Nitrogen	24.0%	65.8%	3.7%
Total Phosphorus	20.0%	44.0%	5.1%
TSS	49.0%	86.7%	19.9%
E coli	88.0%	98.8%	34.2%
Copper	29.0%	97.9%	17.7%

3.7 THE *CREDITS* WORKSHEET

The **Credits** worksheet is used to implement Stormwater Credits for reducing the WQv and CPv Water Quality Criteria. The Credits are designed to encourage the use of practices that store, infiltrate, or treat runoff at or near its source. Centralized structures that collect and manage runoff from an entire site are often necessary and beneficial for flood protection and channel erosion goals, but practices that prevent, reduce, or slow stormwater runoff are often highly effective, and may ultimately reduce costs of conveyance structures and storage basins. Appendix J of the Procedures and Design Standards Manual provides instructions and guidance for using the Stormwater Credits, and it should be used hand in hand with this User Guide when entering the Credits into the SET.

Credits reduce WQv and CPv treatment volumes in a variety of ways. Some credits reduce volume by encouraging practices that substitute land covers which generate less runoff to begin with. These types of credits are tracked in the SET by using the Proposed Land Use Pre-Credit and Post-Credit columns in the **Land Use** worksheet; the Pre-Credit and Post-Credit WQv and CPv are reported on the **Model Output** worksheet. Other credits directly manipulate the WQv and/or CPv calculations to reduce the required treatment volume; the **Credits** worksheet is used to track land area for direct volume reduction for WQv and CPv.

The **Credits** worksheet is configured much like the **DAs** worksheet – each land use type is shown on the left and a grid of cells is used to account for all of the site's land area. However, instead of land area being divided into drainage areas for structural BMPs, land area is assigned to specific qualifying Credits. One of the requirements for implementing Stormwater Credits is that only one Credit may be used on any physical area of the site. In other words, a particular land area can qualify for only one Credit. The **Credits** worksheet entry accounts for the entire site area, and no area can be entered more than once. The

entry area also has a column for portions of the site that do not qualify for any of the Credits. All of the remaining land area must be entered in this column, which accounts for the land area of the entire site.

WQv is scaled to total site area and percent imperviousness. The formula can be summarized as follows:

$$WQv = 3{,}630 \times A \times (0.05 + 0.009I)$$

where A = site area (ac) and I = percent imperviousness.

Most of the Stormwater Credits act by subtracting treated areas from A (in effect, representing the site as being smaller). Some Credits reduce WQv directly, or by some factor. One of the Credits is linked to I. Because site area and percent imperviousness are readily available, the SET performs all calculations needed for WQv and the Stormwater Credits that may reduce it.

CPv is not calculated, but is extrapolated from Table J-2 in the Procedures and Design Standards Manual. The table provides unit area CPv volume keyed to CN and Tc. Changes in CN have a larger effect on CPv, while changes in Tc have a smaller effect on Tc. Most of the Credits act by encouraging practices that reduce CN or increase Tc, thereby decreasing CPv. Note that per the Procedures and Design Standards Manual, curve numbers are shifted upward by one HSG for areas of the site that are cleared for development. In the SET, this is implemented for the "Lawn/Landscaping" and "All Other Pervious Structural BMP Area" land uses. HSG A is shirted to HSB B, HSG B to HSG C, HSG C to HSG D, and HSG D remains D.

Below the main land use entry table, there are several additional entry cells and select boxes used for a variety of purposes:

- The "Water Quality Volume Exemption" is used to specify whether the site uses extended detention to treat the CPv, which exempts the site from WQv treatment requirements.
- The Time of Concentration (Tc) must be entered to calculate CPv. It is always a required input for the Post-Credit land use, and must also be entered when Pre-Credit land use is entered.
- For the Redevelopment Credit, there is a select box to specify whether the CPv was required for the existing developed site (answer "Yes" or "No"). When the Redevelopment Credit is not being taken, "N/A" must be selected.
- If the user wishes to specify weighted site CN that are different from the SET calculated values, (which are shown to the right of the entry boxes), the select box must be changed to "Yes" and the new CNs entered.

Land Cover Group		Land Cover Class	Proposed Site Area (ft2)	Unassinged Area (ft2)	No Credit	Impervious Cover Reduction	Redevelopment	Water Buffer / Filter Strip	Environmentally Sensitive Development	Open Drainage Swale	Conservation of Natural Areas	Reforestation	Afforestation	Impervious Surface Disconnection	Permeable Pavers	Soils Preservation	Green Rooftop
					No Credit	Credit 1	Credit 2	Credit 3	Credit 4	Credit 5	Credit 6	Credit 7a	Credit 7b	Credit 8	Credit 9	Credit 10	Credit 11
Pervious		Agriculture	0	0		Calculated Automatically											
		Pasture (with livestock)	0	0													
		Wetlands	0	0													
		Grassland / Meadow / Savannah	0	0													
		Forest / Woods	234,000	0									234,000				
		Lawn / Landscaping	604,200	0	261,700					342,500							
Impervious	Residential, Office, Institutional	Rooftops	150,000	0	21,300					128,700							
		Driveways & Parking Lots	124,000	0	13,110					110,890							
		Other Impervious Area	0	0													
		Road	119,800	0	5,080					114,720							
		Sidewalk	32,000	0						32,000							
	Commercial & Heavy Industrial	Rooftops	0	0													
		Parking Lots	0	0													
		Other Impervious Area	0	0													
		Road	0	0													
		Sidewalk	0	0													
Stormwater Management		Pond/Open Water Surface Area	0	0													
		Green Roof	0	0													
		Porous Pavement	7,800	0											7,800		
		All Other Pervious Structural BMP Area	35,000	0	35,000												
		Total Assigned Area	1,306,800	0	336,190		0	0	0	728,810	0	0	234,000	0	7,800	0	0

Total area matches

Water Quality Volume Exemption

Is extended detention provided for the Channel Protection Volume?	No

Channel Protection Volume required input - Enter Tc values (minutes)

Pre-credit Time of Concentration (Tc, minutes)	15
Post-credit Time of Concentration (Tc, minutes)	20

Specify values as needed for these credits

Redevelopment Credit: Was CPv previously required at the site?	N/A
Imperv. Surface Disconnection Credit: Estimate volume reduction (ft^3)	0

User-defined weighted site CN	Specify?	Enter CN	SET value
Pre-credit Curve Number	Yes	88	86.3
Post-credit Curve Number		85	83.6

Each Stormwater Credit is discussed briefly below. Refer to Appendix J of the Procedures and Design Standards Manual for further information related to requirements, restrictions, and design details.

Credit 1: Impervious Cover Reduction Credit

Implementation. This credit is incorporated directly into the site impervious area as defined by the Post-Credit site plan. There is no land area entry required for this credit. Rather, the influence of this credit is calculated by entering the Pre-Credit Proposed Land Use on the **Land Use** worksheet, and comparing the results on the **Model Output** worksheet.

WQv. Reducing impervious surface reduces the WQv directly.

CPv. Reducing impervious surface lowers the weighted site CN, thereby reducing the CPv.

Credit 2: Redevelopment Credit

Implementation. A site is considered either redevelopment or new development, never a combination of both. If a site qualifies for the Redevelopment Credit, then the entire site must be entered in the *Credit 2* column. The SET provides a warning to ensure no site area is entered in a different column.

WQv. The credit takes two tracks:

Is the post-developed impervious area reduced by 25% or more from the existing impervious area?

Yes	No
$WQv' = 0$	$C = I_p \times WQv_p$ $WQv' = WQv - C$
where WQv' = post-credit adjusted WQv	where I_p = pre-developed impervious cover WQv_o = WQv for pre-developed site WQv' = post-credit adjusted WQv

CPv. CPv = 0 unless a CPv was previously required at the site. Use the checkbox below the table to indicate whether a CPv was previously required (you must change the selection from "N/A" to "Yes" or "No").. If CPv was previously required, the SET does not calculate the new CPv but instead refers the user to the County Engineering Department for consultation, which is indicated on the **Model Output** worksheet.

Credit 3: Waterway Buffer/Filter Strip Credit

Implementation. Area qualifying for this credit is entered in the *Credit 3* column.

WQv. The area entered in the *Credit 3* column is subtracted from *A* in the WQv calculation.

CPv. The area in the *Credit 3* column is assigned to the CN for "woods in good condition," using the appropriate post-developed CN for the site according to the HSG ratios entered in the **Site Data** worksheet.

Credit 4: Environmentally-Sensitive Development Credit

Implementation. The entire site area must be entered into the *Credit 4* column. The SET provides a warning to ensure no site area is entered in a different column.

WQv. The WQv is set equal to 0.

CPv. The site will tend to have lower runoff by virtue of the requirements of the credit. The influence of this credit is seen by entering the Pre-Credit Proposed Land Use on the **Land Use** worksheet, and comparing the results on the **Model Output** worksheet. Any changes in Tc would be included in the user's calculation.

Credit 5: Open Drainage Swale Credit

Implementation. Area qualifying for this credit is entered in the *Credit 5* column.

WQv. The area entered in the *Credit 5* column is subtracted from *A* in the WQv calculation.

CPv. Any changes in Tc would be included in the user's calculation.

Credit 6: Conservation of Natural Areas Credit

Implementation. Area qualifying for this credit is entered in the *Credit 6* column. Only undeveloped land covers may be specified for this credit.

WQv. The area entered in the *Credit 6* column is subtracted from *A* in the WQv calculation.

CPv. The site will tend to have lower runoff since undeveloped uses tend to have lower CNs than developed uses. The influence of this credit is seen by entering the Pre-Credit Proposed Land Use on the **Land Use** worksheet, and comparing the results on the **Model Output** worksheet. Any changes in Tc would be included in the user's calculation.

Credit 7a: Reforestation Credit

Implementation. Note that *Credit 7* in the Procedures and Design Standards Manual is split into *Credit 7a* and *Credit 7b* in the SET due to the difference in calculation for reforestation versus afforestation. The area qualifying for this credit is entered in the *Credit 7a* column. Only forest area may be specified for this credit.

WQv. In the WQv calculation, 0.5 times area entered in the *Credit 7a* column is subtracted from *A*.

CPv. The site will tend to have lower runoff since forest has lower CNs than developed uses. The influence of this credit is seen by entering the Pre-Credit Proposed Land Use on the **Land Use** worksheet, and comparing the results on the **Model Output** worksheet. Any changes in Tc would be included in the user's calculation.

Credit 7b: Afforestation Credit

Implementation. Note that *Credit 7* in the Procedures and Design Standards Manual is split into *Credit 7a* and *Credit 7b* in the SET due to the difference in calculation for reforestation versus afforestation. Area qualifying for this credit is entered in the *Credit 7b* column. Only forest area may be specified for this credit.

WQv. In the WQv calculation, 1.5 times area entered in the *Credit 7a* column is subtracted from *A*.

CPv. The site will tend to have lower runoff since forest has lower CNs than developed uses. The influence of this credit is seen by entering the Pre-Credit Proposed Land Use on the **Land Use** worksheet, and comparing the results on the **Model Output** worksheet. Any changes in Tc would be included in the user's calculation.

Credit 8: Impervious Surface Disconnection Credit

Implementation. Area qualifying for this credit is entered in the *Credit 8* column. The Procedures and Design Standards Manual does not provide specific guidelines for calculating adjustments to the WQv. The amount of the credit will be decided by the County in consultation with the developer during the design review process. However, the SET includes a box below the table for user-entry of the credit, and the user can provide an educated guess.

WQv. Enter an educated guess (in cubic feet) in the appropriate box below the table. An agreed-upon value can be entered during later stages of the design review process.

CPv. The Manual does not provide specific guidelines for calculating adjustments to the Tc. However, the user can make an educated guess in the calculation of Tc and confirm the value during the design review process.

Credit 9: Permeable Pavers Credit

Implementation. Permeable pavement area qualifying for this credit is entered in the *Credit 9* column.

WQv. In the WQv calculation, one-half of the area entered in the *Credit 9* column is subtracted from *A*.

CPv. No CN adjustment is provided for this credit. Any changes in Tc would be included in the user's calculation.

Credit 10: Soils Preservation Credit

Implementation. Area qualifying for this credit is entered in the *Credit 10* column. Only undeveloped land covers may be specified for this credit.

WQv. The area entered in the *Credit 6* column is subtracted from *A* in the WQv calculation.

CPv. The site will tend to have lower runoff since undeveloped uses tend to have lower CNs than developed uses. The influence of this credit is seen by entering the Pre-Credit Proposed Land Use on the **Land Use** worksheet, and comparing the results on the **Model Output** worksheet. Any changes in Tc would be included in the user's calculation.

Credit 11: Green Rooftop Credit

Implementation. Green roof area qualifying for this credit is entered in the *Credit 11* column.

WQv. A qualifying site with a green roof will have total exemption for the WQv. Note that the green roof must occupy a significant portion of the site's footprint. The designer would need to confirm whether the site qualifies for this credit with the County.

CPv. The impervious area in the Credit 11 column will have an adjusted CN of 30 applied to it, providing a significant reduction in CPv. Any changes in Tc would be included in the user's calculation.

3.8 THE *MODEL OUTPUT* WORKSHEET

The **Model Output** worksheet is divided into six sections:

- Land Use Summary
- Annual Hydrology Summary
- Annual Pollutant Load and Loading Rates (Entire Site)
- TSS Maximum Allowable Concentration Summary
- BMP Performance Summary
- Stormwater Credits Summary

The Excel print area has been pre-set to print all the results on two 8 ½ x 11 sheets, although you may print any area desired. The *Project Information* from the **Site Data** worksheet is displayed at the top of the **Model Output** worksheet, and also at the top of each of the two sheets.

Macomb County Site Evaluation Tool
Company Name
Address, etc.
Scenario #1

The "Land Use Summary" lists site area and pre- and post-impervious percentages and other information relevant to the site.

Land Use Summary

Total Site Area (acres)	**30**
Pre-development impervious percentage	**0.0%**
Post-development impervious percentage	**33.2%**

The "Annual Hydrology Summary" section shows annual hydrology results for the project area prior to development (purple), the Post-Credit site without BMPs (blue), and the Post-Credit site with BMPs (green). These include annual surface runoff and infiltration (in inches/year). Development generally results in a decrease in infiltration and an increase in runoff. Some BMPs are able to reduce surface runoff and increase infiltration. These values are rough estimates only, but are important for understanding the impact of development on annual hydrology. The color scheme used here is retained throughout the **Model Output** worksheet.

Annual Hydrology Summary

	Existing Landuse	Post-Credit without BMPs	Post-Credit with BMPs
Annual Surface Runoff (inches/yr)	**1.41**	**12.17**	**7.07**
Annual Infiltration (inches/yr)	**6.72**	**3.83**	**4.67**

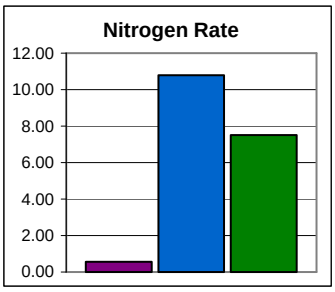
The "Annual Pollutant Load and Loading Rates (Entire Site)" section provides information about total site loads and per-acre loading rates for each of the five evaluated pollutants. These represent surface loads only, and do not include groundwater contributions as discussed in the Introduction. The loads and areal loading rates presented here are for the entire site. Graphs are provided for areal loading rates.

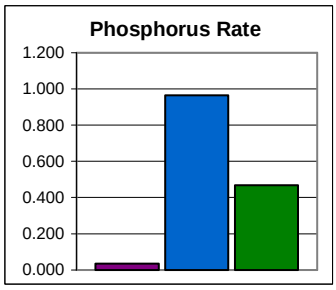
BMPs provide the means for reducing loads. When you select BMPs, the SET calculates the appropriate load reduction and recalculates the post-development load. You may select other BMPs to test various configurations and find the optimal solution relative to feasibility and anticipated cost. The SET provides an easy way to see how well the BMPs perform.

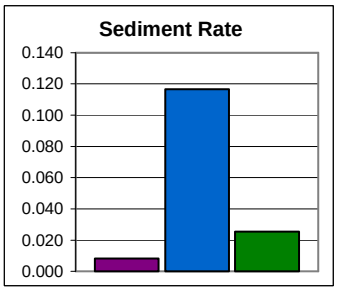
Annual Pollutant Load and Loading Rates (Entire Site)

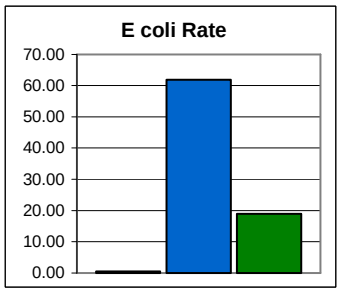
Annual Surface Loads	Existing Landuse	Post-Credit without BMPs	Post-Credit with BMPs
Total Nitrogen (lb/yr)	17	324	225
Total Phosphorus (lb/yr)	1.1	28.9	14.0
Sediment (ton/yr)	0.244	3.495	0.760
E coli (# x 10^9/yr)	14	1,856	569
Copper (lb/yr)	0.032	2.478	1.085

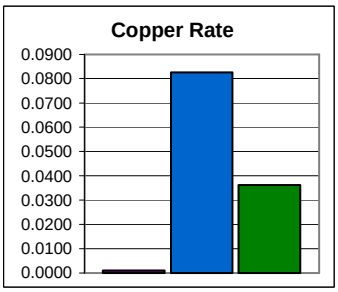
Annual Surface Loading Rates	Existing Landuse	Post-Credit without BMPs	Post-Credit with BMPs
Total Nitrogen (lb/ac/yr)	0.55	10.80	7.49
Total Phosphorus (lb/ac/yr)	0.035	0.964	0.467
Sediment (ton/ac/yr)	0.008	0.116	0.025
E coli (# x 10^9/ac/yr)	0.48	61.86	18.97
Copper (lb/ac/yr)	0.0011	0.0826	0.0362











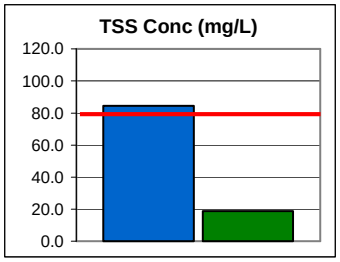
The "TSS Maximum Allowable Concentration Summary" provides a tabular and graphical evaluation of the Post-Credit site's performance for the maximum TSS concentration Water Quality Criterion. The average concentration is shown before and after application of structural BMPs. The bar on the graph designates the 80 mg/L standard. When the target is not met, the **Model Output** worksheet will show the following visual indicator:

NO!

In the example shown below, the site's concentration must be reduced to meet the 80 mg/L standard. The selected BMPs reduce the concentration and the site therefore meets the standard. As noted previously in the Introduction, the SET's calculation of sediment concentration differs somewhat from the one provided in the Procedures and Design Standards Manual, but the two methods are fundamentally similar since they are based on the same monitoring data. The developer may elect to use either method for evaluation of compliance with the standard.

TSS Maximum Allowable Concentration Summary

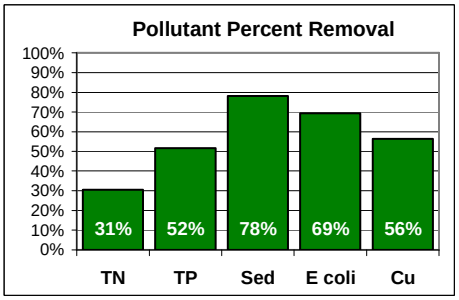
Evaluation	TSS (mg/L)
Post-Credit without BMPs	84.4
Post-Credit with BMPs	18.8
Maximum allowable concentration	80.0
Meets Standard?	Yes



The "BMP Performance Summary" shows how well the structural BMPs selected on the **BMPs** worksheet reduced post development loads. The evaluation is performance relative to the Post-Credit site configuration. It includes the combined effect of all BMPs.

BMP Performance Summary

Pollutant	Post-Credit without BMPs	Post-Credit with BMPs	% Removal
Total Nitrogen (lb/yr)	324	225	30.6%
Total Phos. (lb/yr)	28.9	14.0	51.6%
Sediment (ton/yr)	3.495	0.760	78.3%
E coli (# x 10^9/yr)	1,856	569	69.3%
Copper (lb/yr)	2.478	1.085	56.2%



The "Stormwater Credits Summary" shows the Pre-Credit and Post-Credit WQv and CPv for the site.

The Pre-Credit values are based on the land use data entered in the *Proposed Land Use, Pre-Credit* column on the Land Use worksheet. The Pre-Credit WQv and CPv are provided for educational purposes only, as noted in Section 3.4. When the Pre-Credit land use is omitted, the values will display "Not Specified."

The Post-Credit values represent the required treatment volumes for WQv and CPv. They include all the reductions gained by applying Stormwater Credits, if utilized. In some cases, the WQv and CPv are not required (as specified by the user at the bottom of the **Credits** worksheet). In those cases, the values will display "Not Required" and additional information is provided to the right.

Stormwater Credits Summary

	Pre-Credit	Post-Credit	
Water Quality Volume (ft^3)	41,509	Not Required	Extended detention provided for site
Channel Protection Volume (ft^3)	75,236	64,828	

3.9 SPECIAL CASE DRAINAGE AREAS

It is critical that you divide up drainage areas properly in order to obtain accurate results. The entire site area must be accounted for when drainage areas are defined. Frequently it is difficult to apply the strict interpretation of drainage areas to the realities of a site plan. This section provides guidance to handling some circumstances that might be encountered by the user. In many cases, like areas can be lumped together into one "drainage area" even though in reality they drain to separate locations.

Areas of the site that do not drain to a BMP

All areas of the site that do not drain to a BMP may be lumped together into a single "drainage area." An example is a case where several edges of the site drain offsite in many directions.

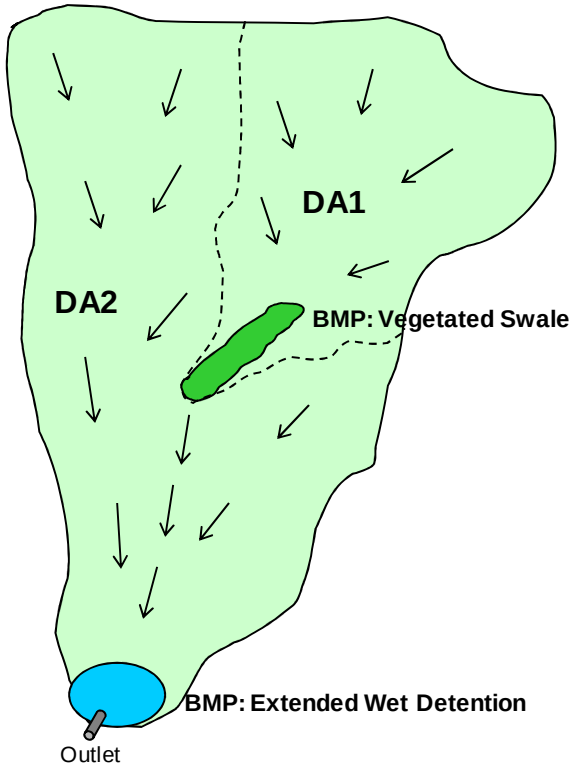
Connecting Drainage Areas

In some cases, a drainage area with one BMP may drain to another drainage area with a different BMP. The treated water leaving the first drainage area has reduced pollutant levels, and then the water enters the second BMP and receives further treatment. The second BMP receives runoff from both an untreated area and from the first drainage area. The SET allows for this configuration and calculates the total pollutant reduction appropriately.

For instance, the figure shows a site with two BMPs – a vegetated swale and an extended wet detention basin. The entire site drains to the extended wet detention basin, but the portion inside the dotted line drains to the vegetated swale.

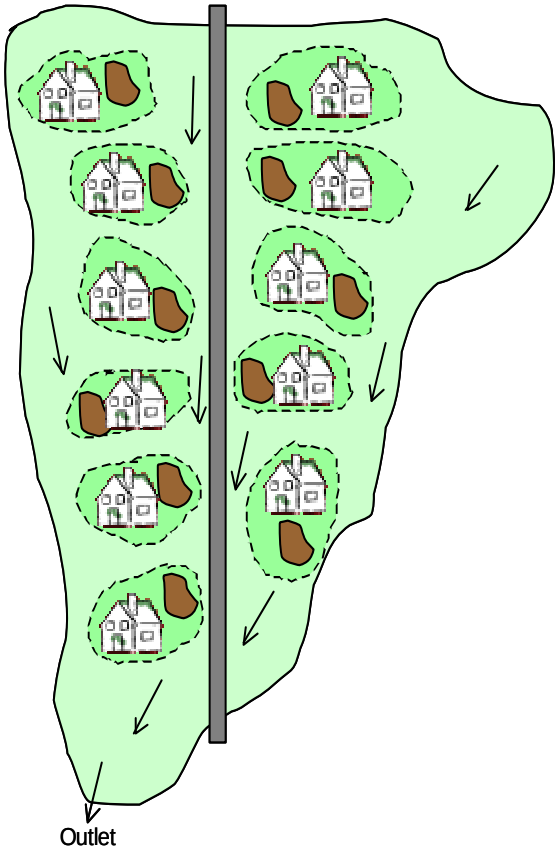
In this example, let's say the entire site is 10 acres and the portion draining to the vegetated swale is 3 acres. You would set up two drainage areas (DAs) in the SET. DA1 has a total area of 3 acres, and DA2 has a total area of 7 acres, totaling 10 acres.

You would then select "Extended Wet Detention" for DA2. The portion of the site called DA2 drains to the extended wet detention basin only and receives no other treatment. For DA1, you would select both "Vegetated Swale" and "Extended Wet Detention." DA1 drains to the vegetated swale, and the treated water continues on to the pond and receives further treatment.



Dispersed Bioretention Cells

Bioretention cells (sometimes called "Rain Gardens") are frequently designed to treat small areas (no more than five acres) and are dispersed throughout the site. For instance, a housing development might have individual bioretention cells treating runoff at each house. Obviously it would be difficult to define 20+ drainage areas. In this case, you would take the true drainage area and divide it up into two "virtual" drainage areas – the portion of the drainage area treated by bioretention, and the portion not treated by bioretention.

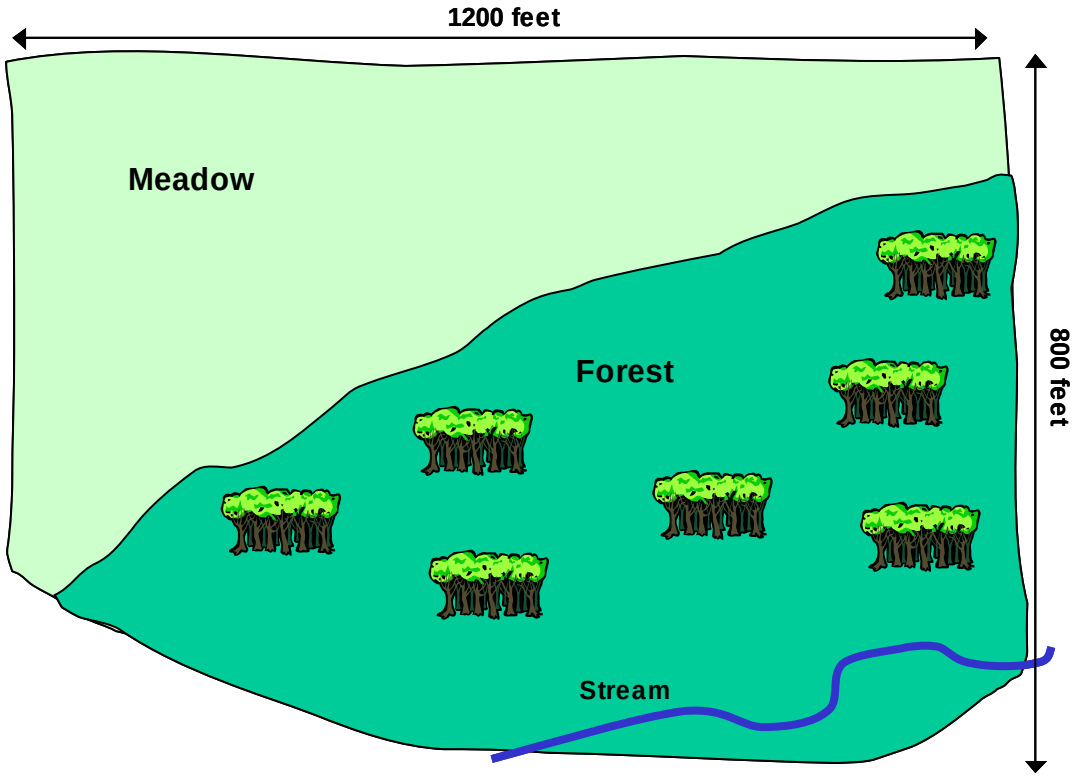


In the example shown, there are 11 houses on the 10- acre site. The bioretention cells are shown in brown next to the houses, and the area surrounding each house draining to the house's bioretention cell is shown in darker green. Let's say that each of the darker green sub-drainage areas is 0.4 acres in size. That means 4.4 acres of the true 10-acre drainage area are treated by bioretention cells. The remaining 5.6 acres is not treated. You would set up two drainage areas in the SET. The first has land use and impervious areas contained inside the darker green zones, with a total area of 4.4 acres. You would then set up a second drainage area for the remaining land use, with a total area of 5.6 acres. Even though technically there are 11 BMPs, they can be aggregated since they serve the same purpose.

4 Example Site Design

The following example illustrates how to represent a site plan in the Macomb County SET. Two designs are explored – a "conventional" design using traditional means of stormwater management, and an "innovative" design that uses some non-standard approaches. The innovative design utilizes a number of Stormwater Credits for the reduction of WQv and CPv, and the structural BMPs provide better pollutant removal.

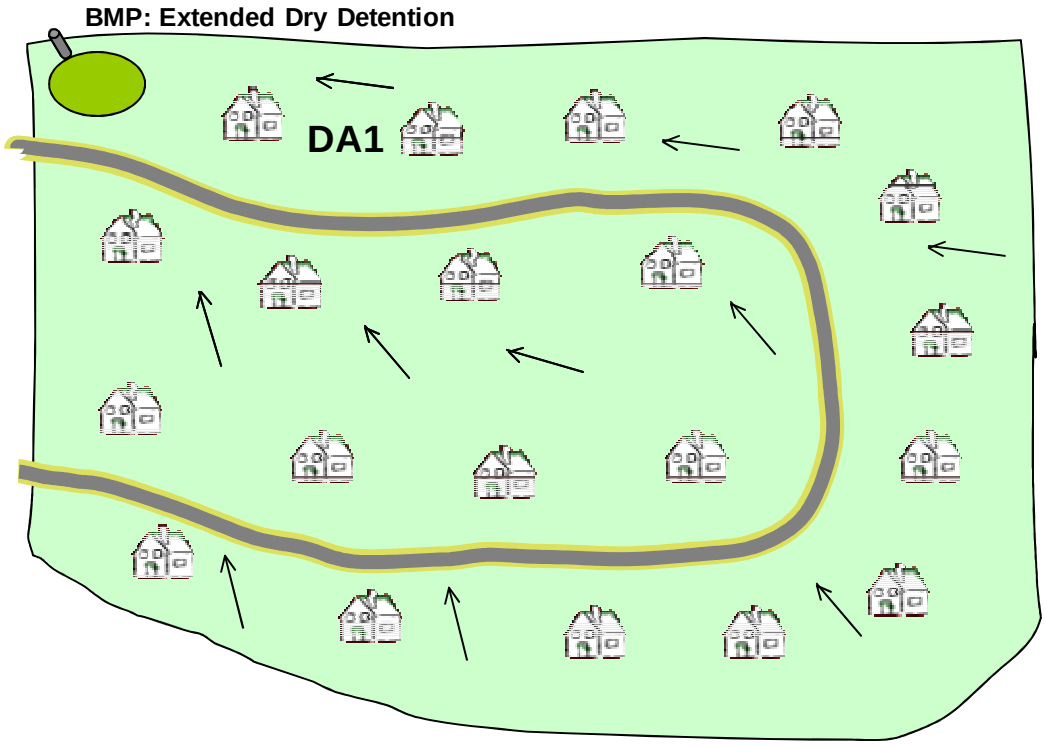
The site is 20 acres in size, and the developer plans to place 20 new homes on the site. In its undeveloped state, the site has 12 acres (522,720 ft^2) of forest and 8 acres (348,480 ft^2) of meadow. The site has 35 percent Group C soils and 65 percent Group D soils. The roads have curb and gutter, and sidewalks are located on both sides of the street.



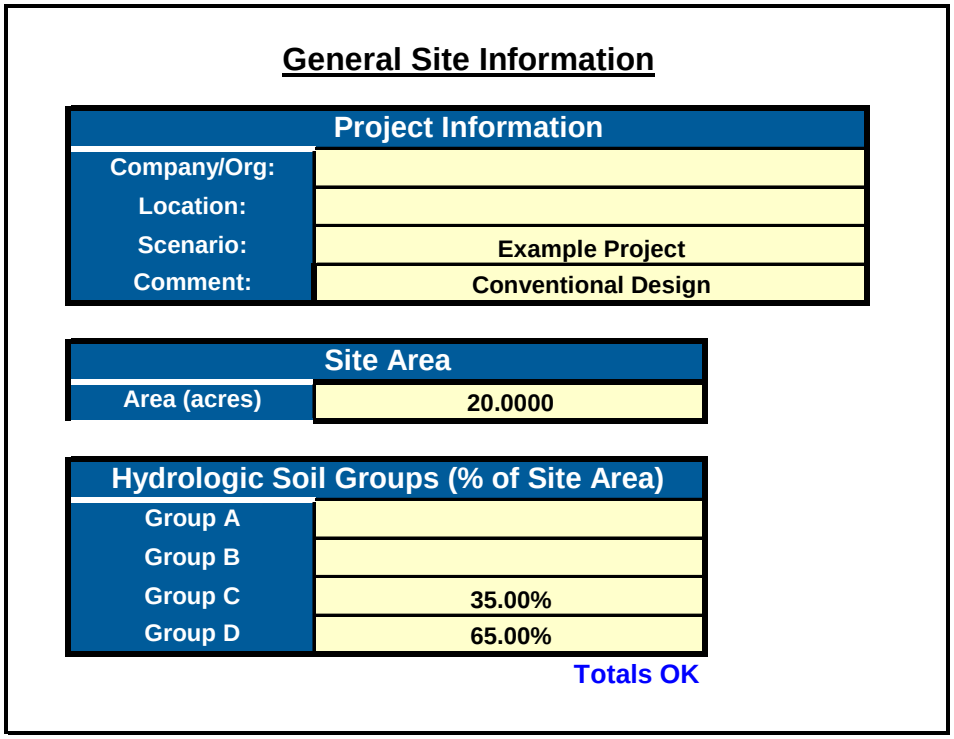
In the first development scenario, the entire site is utilized producing an average lot size of 1.0 acres. Within each lot, the typical dimensions are as follows:

- House – 2,500 ft^2
- Driveway – 1,300 ft^2 (20 ft x 65 ft)
- Patio, entry sidewalk, etc. – 400 ft^2

The road is 2,020 feet in length, with a width of 28 feet (including curb and gutter). Five foot sidewalks line sides of the road (assumed average length 2,020 feet). An extended dry detention basin with a footprint of 12,300 ft^2 provides treatment for the entire site.



The user enters the relevant data in the **Site Data** worksheet.



General Site Information

Project Information	
Company/Org:	
Location:	
Scenario:	Example Project
Comment:	Conventional Design

Site Area	
Area (acres)	20.0000

Hydrologic Soil Groups (% of Site Area)	
Group A	
Group B	
Group C	35.00%
Group D	65.00%

Totals OK

The pre-development land use is entered into the Existing Land Use column. For the proposed site, the land use is entered into the Proposed Land Use Post-Credit column. Note that the Pre-Credit column is not used – this site design is the starting point, and it will be compared to the alternative design in the next example.

Land Use Entry

☐ Enter Pre-Credit Proposed Land Use

Land Cover Group		Land Cover Class	Existing Land Use		Proposed Land Use			
					Pre-Credit		Post-Credit	
			Area (ft^2)	% of Site	Area (ft2)	% of Site	Area (ft^2)	% of Site
Pervious		Agriculture		0.0%				0.0%
		Pasture (with livestock)		0.0%				0.0%
		Wetlands		0.0%				0.0%
		Grassland / Meadow / Savannah	348,480	40.0%				0.0%
		Forest / Woods	522,720	60.0%				0.0%
		Lawn / Landscaping		0.0%			689,400	79.1%
Impervious	Residential, Office, Institutional	Rooftops		0.0%			50,000	5.7%
		Driveways & Parking Lots		0.0%			26,000	3.0%
		Other Impervious Area		0.0%			8,000	0.9%
		Road		0.0%			63,000	7.2%
		Sidewalk		0.0%			22,500	2.6%
	Commercial & Heavy Industrial	Rooftops		0.0%				0.0%
		Parking Lots		0.0%				0.0%
		Other Impervious Area		0.0%				0.0%
		Road		0.0%				0.0%
		Sidewalk		0.0%				0.0%
Stormwater Management		Pond/Open Water Surface Area		0.0%				0.0%
		Green Roof		0.0%				0.0%
		Porous Pavement		0.0%				0.0%
		All Other Pervious Structural BMP Area		0.0%			12,300	1.4%
Site Totals:			871,200	100.0%			871,200	100.0%
Check Land Use Totals:			Equals Site Area				Equals Site Area	
Percent Impervious Cover			0.00%				19.46%	

The site has one drainage area (DA1) served entirely by an extended dry detention basin. The user calculates the pervious and impervious areas for each individual drainage area and puts the totals into the **DAs** worksheet:

Land Cover Group		Land Cover Class	Proposed Site Area (ft2)	Unassinged Area (ft2)	DA1	DA2
Pervious		Agriculture	0	0		
		Pasture (with livestock)	0	0		
		Wetlands	0	0		
		Grassland / Meadow / Savannah	0	0		
		Forest / Woods	0	0		
		Lawn / Landscaping	689,400	0	689,400	
Impervious	Residential, Office, Institutional	Rooftops	50,000	0	50,000	
		Driveways & Parking Lots	26,000	0	26,000	
		Other Impervious Area	8,000	0	8,000	
		Road	63,000	0	63,000	
		Sidewalk	22,500	0	22,500	
	Commercial & Heavy Industrial	Rooftops	0	0		
		Parking Lots	0	0		
		Other Impervious Area	0	0		
		Road	0	0		
		Sidewalk	0	0		
Stormwater Management		Pond/Open Water Surface Area	0	0		
		Green Roof	0	0		
		Porous Pavement	0	0		
		All Other Pervious Structural BMP Area	12,300	0	12,300	
Total Area			871,200	0	871,200	

Proposed Drainage Area (DA) assignments match Proposed Land Use.

The user then checks off the applicable BMP for DA1 in the **BMPs** worksheet.

BMPs	DA1
Extended Wet Detention	☐
Extended Dry Detention	☑
Infiltration Basin	☐
Bioretention	☐
Sand Filter	☐
Infiltration Trench	☐
Vegetated Swale	☐
Bioswale	☐
Vegetated Filter Strip	☐
Dry Well	☐
Rain Barrels	☐
Cistern	☐
Hydrodynamic Device	☐
Catch Basin with Sump	☐
User-defined BMP	☐
Green Roof	N/A
Porous Pavement	N/A

The net reduction efficiencies for the selected BMP are:

Net Reductions for each DA	DA1
Annual runoff converted to Infiltration + ET	15.0%
Total Nitrogen	24.0%
Total Phosphorus	20.0%
TSS	49.0%
E coli	88.0%
Copper	29.0%

The site does not qualify for any Stormwater Credits. As a result, the entire site area is entered into the No Credit column on the **Credits** worksheet.

Land Cover Group		Land Cover Class	Proposed Site Area (ft2)	Unassinged Area (ft2)	No Credit	Impervious Cover Reduction	Redevelopment	Water Buffer / Filter Strip	Environmentally Sensitive Development	Open Drainage Swale	Conservation of Natural Areas	Reforestation	Afforestation	Impervious Surface Disconnection	Permeable Pavers	Soils Preservation	Green Rooftop
					No Credit	Credit 1	Credit 2	Credit 3	Credit 4	Credit 5	Credit 6	Credit 7a	Credit 7b	Credit 8	Credit 9	Credit 10	Credit 11
Pervious		Agriculture	0	0		Calculated Automatically											
		Pasture (with livestock)	0	0													
		Wetlands	0	0													
		Grassland / Meadow / Savannah	0	0													
		Forest / Woods	0	0													
		Lawn / Landscaping	689,400	0	689,400												
Impervious	Residential, Office, Institutional	Rooftops	50,000	0	50,000												
		Driveways & Parking Lots	26,000	0	26,000												
		Other Impervious Area	8,000	0	8,000												
		Road	63,000	0	63,000												
		Sidewalk	22,500	0	22,500												
	Commercial & Heavy Industrial	Rooftops	0	0	0												
		Parking Lots	0	0	0												
		Other Impervious Area	0	0	0												
		Road	0	0	0												
		Sidewalk	0	0	0												
Stormwater Management		Pond/Open Water Surface Area	0	0	0												
		Green Roof	0	0	0												
		Porous Pavement	0	0	0												
		All Other Pervious Structural BMP Area	12,300	0	12,300												
		Total Assigned Area	871,200	0	871,200		0	0	0	0	0	0	0	0	0	0	0
Total area matches																	

Continuing on the **Credits** worksheet, the following selections are made. Extended detention is provided for the CPv, so the requirement for WQv is automatically met. The user therefore selects "Yes" to the Water Quality Volume Exemption question. Since the Pre-Credit land use is not specified on the **Land Use** worksheet, the Pre-Credit Tc is not required and is grayed out. The Post-Credit Tc is 20 minutes. The Redevelopment Credit was not used, so "N/A" is selected, and there is no Impervious Surface Disconnection Credit estimated volume reduction. Finally, the user is not supplying the weighted site CNs.

Water Quality Volume Exemption

Is extended detention provided for the Water Quality Volume?	Yes

Channel Protection Volume required input - Enter Tc values (minutes)

Pre-credit Time of Concentration (Tc, minutes)	
Post-credit Time of Concentration (Tc, minutes)	20

Specify values as needed for these credits

Redevelopment Credit: Was CPv previously required at the site?	N/A
Imperv. Surface Disconnection Credit: Estimate volume reduction (ft^3)	0

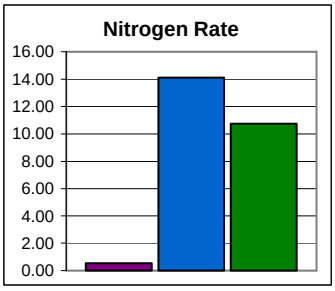
User-defined weighted site CN	Specify?	CN
Pre-credit Curve Number	No	
Post-credit Curve Number		

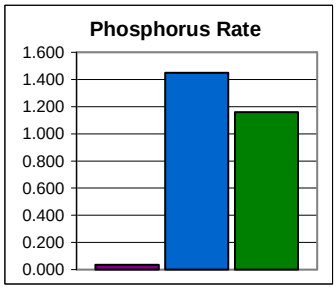
Moving to the **Model Output** worksheet, the selected BMP reduces the pollutant loads to some degree, but do not provide a high level of treatment.

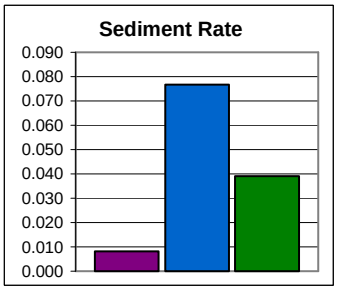
Annual Pollutant Load and Loading Rates (Entire Site)

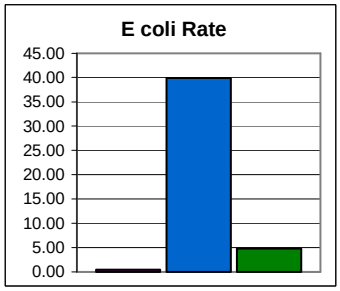
Annual Surface Loads	Existing Landuse	Post-Credit without BMPs	Post-Credit with BMPs
Total Nitrogen (lb/yr)	11	283	215
Total Phosphorus (lb/yr)	0.7	29.0	23.2
Sediment (ton/yr)	0.162	1.533	0.782
E coli (# x 10^9/yr)	10	798	96
Copper (lb/yr)	0.021	1.033	0.733

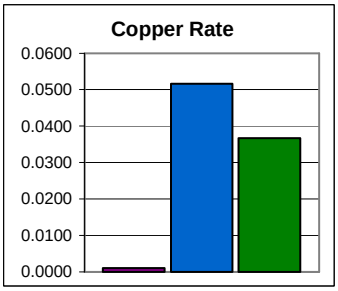
Annual Surface Loading Rates	Existing Landuse	Post-Credit without BMPs	Post-Credit with BMPs
Total Nitrogen (lb/ac/yr)	0.55	14.13	10.74
Total Phosphorus (lb/ac/yr)	0.035	1.450	1.160
Sediment (ton/ac/yr)	0.008	0.077	0.039
E coli (# x 10^9/ac/yr)	0.48	39.89	4.79
Copper (lb/ac/yr)	0.0011	0.0516	0.0367





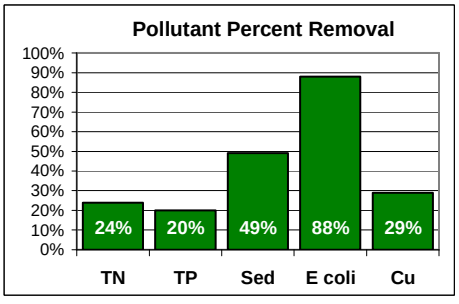






BMP Performance Summary

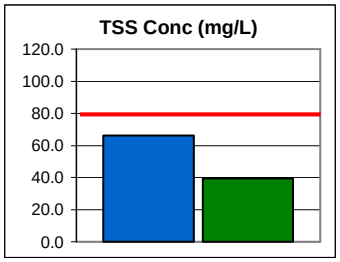
Pollutant	Post-Credit without BMPs	Post-Credit with BMPs	% Removal
Total Nitrogen (lb/yr)	283	215	24.0%
Total Phos. (lb/yr)	29.0	23.2	20.0%
Sediment (ton/yr)	1.533	0.782	49.0%
E coli (# x 10^9/yr)	798	96	88.0%
Copper (lb/yr)	1.033	0.733	29.0%



The Post-Credit site meets the Maximum Allowable TSS Concentration standard even without the addition of BMPs; the extended dry detention basin further reduces the concentration.

TSS Maximum Allowable Concentration Summary

Evaluation	TSS (mg/L)
Post-Credit without BMPs	66.1
Post-Credit with BMPs	39.7
Maximum allowable concentration	80.0
Meets Standard?	Yes

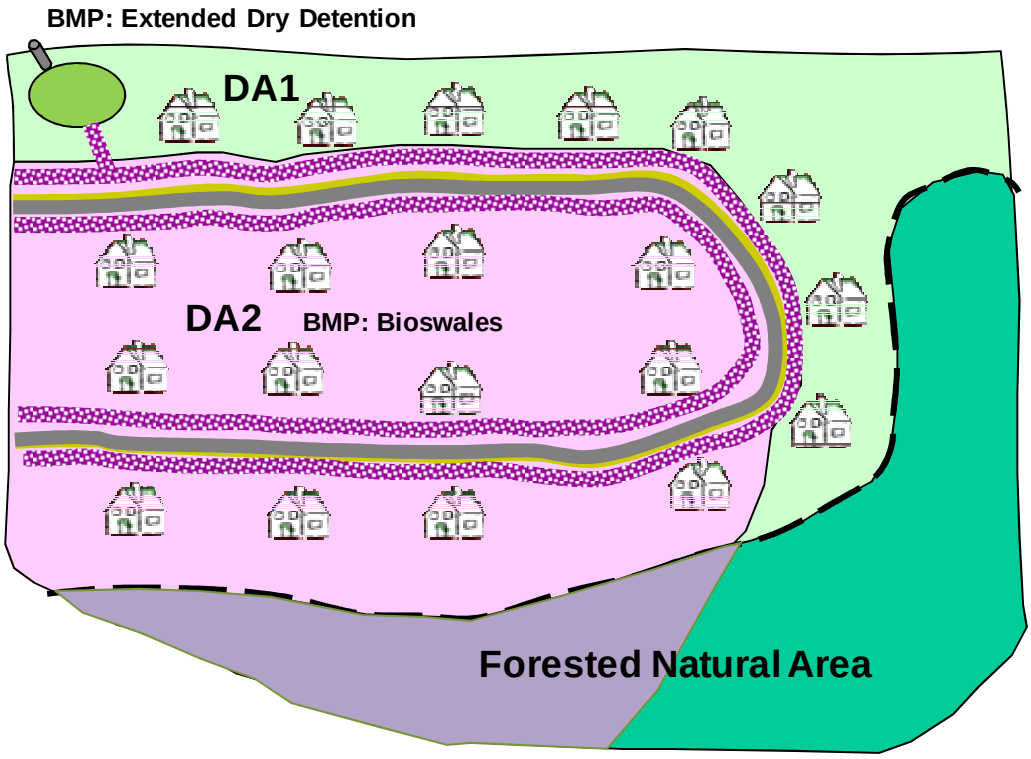


The Stormwater Credits Summary shows the Post-Credit CPv; treatment of the WQv is not required.

Stormwater Credits Summary

	Pre-Credit	Post-Credit	
Water Quality Volume (ft^3)	Not Specified	Not Required	Extended detention provided for site
Channel Protection Volume (ft^3)	Not Specified	42,684	

How can this project be modified to achieve better overall pollutant removal and reduce the required CPv? There are several options. Decreasing impervious area decreases runoff, which in turn may decrease pollutant loading. Alternate BMPs may also be selected and combined that have better removal rates. Part of the site could remain in forest cover, or be dedicated to permanent open space with conservation easement. A decrease in impervious cover and increase in forest cover will also lower the weighted site CN, thereby reducing the CPv. The following scenario incorporates all of these features.



The site has a similar layout, but the lots have been clustered and the overall developed area footprint reduced. As a result, about five acres of forest have been preserved. By reducing the size of the development, the street and sidewalk area has been reduced as well, resulting in less impervious surface. The road width has been reduced by eliminating curb and gutter. Sidewalks line one side of the street instead of both sides. Houses have been moved closer to the road, reducing driveway area. In addition, the following changes are made to the structural BMP configuration:

- Biowales line the roads, replacing curb and gutter (not to scale).
- The bioswales convey runoff to the extended dry detention basin, forming a treatment train and allowing for additional pollutant removal.

Drainage Area 1 has now been split into Drainage Areas 1 and 2. The portions of the site draining to the bioswales (DA2)are shown in pink (developed area) and purple (forest); this land area is treated by both the bioswales and the extended dry detention basin. The portions of the site draining to the extended dry detention basin only (DA1) are shown in light green (developed area) and dark green (forest). Land area is broken down in each drainage area as follows:

Element	DA1	DA2	Total
House	8 houses 2,500 ft^2 each 20,000 ft^2 total area	12 houses 2,500 ft^2 each 30,000 ft^2 total area	50,000 ft^2
Driveway	8 driveways 20 ft x 55 ft = 1,100 ft^2 each 8,800 ft^2 total area	12 driveways 20 ft x 55 ft = 1,100 ft^2 each 13,200 ft^2 total area	22,000 ft^2
Patio, entry sidewalk, etc.	8 lots 400 ft^2 each 3,200 ft^2 total area	12 lots 400 ft^2 each 4,800 ft^2 total area	8,000 ft^2
Road	n/a	1,920 ft x 24 ft = 45,840 ft^2	45,840 ft^2
Sidewalk	n/a	1,920 ft x 5 ft = 9,550 ft^2	9,550 ft^2
Structural BMPs	Extended Dry Detention 12,300 ft2 basin	Bioswales 5 ft swale width 1,830 ft average length* Two road sides 18,300 ft^2 total area	30,600 ft^2
Lawn	217,990 ft^2	267,220 ft^2	485,210 ft^2
Forest	136,400 ft^2	83,600 ft^2	220,000 ft^2
Total	*398,690 ft^2*	*472,510 ft^2*	*871,200 ft^2*

* Bioswales length less than road length due to driveway and entrance gaps

Note that this is just an example – impervious area can be reduced in other ways besides leaving out sidewalks or reducing road width, and the chosen BMPs may not be realistic for many developments. The purpose of the example is to understand in general what steps can be taken to reduce pollutant loading and required treatment volume, and also to show how to represent various scenarios in the Site Evaluation Tool.

The user modifies the areas in the **Land Use** worksheet. The "Enter Pre-Credit Proposed Land Use" box is checked, and the land use from the previous example is moved into the Proposed Land Use Pre-Credit column, allowing for comparison of the difference in CPv due to changes in land use. The land use for the modified design is entered in the Proposed Land Use Post-Credit column. Note the addition of the forest area, as well as an impervious surface reduction from 19.46% to 15.54%. The areas of the bioswales and extended dry detention basin have been accounted for under the "Storm Water Management Facilities" section at the bottom.

Land Use Entry

☑ Enter Pre-Credit Proposed Land Use

Land Cover Group		Land Cover Class	Existing Land Use		Proposed Land Use			
					Pre-Credit		Post-Credit	
			Area (ft^2)	% of Site	Area (ft2)	% of Site	Area (ft^2)	% of Site
Pervious		Agriculture		0.0%		0.0%		0.0%
		Pasture (with livestock)		0.0%		0.0%		0.0%
		Wetlands		0.0%		0.0%		0.0%
		Grassland / Meadow / Savannah	348,480	40.0%		0.0%		0.0%
		Forest / Woods	522,720	60.0%		0.0%	220,000	25.3%
		Lawn / Landscaping		0.0%	689,400	79.1%	485,210	55.7%
Impervious	Residential, Office, Institutional	Rooftops		0.0%	50,000	5.7%	50,000	5.7%
		Driveways & Parking Lots		0.0%	26,000	3.0%	22,000	2.5%
		Other Impervious Area		0.0%	8,000	0.9%	8,000	0.9%
		Road		0.0%	63,000	7.2%	45,840	5.3%
		Sidewalk		0.0%	22,500	2.6%	9,550	1.1%
	Commercial & Heavy Industrial	Rooftops		0.0%		0.0%		0.0%
		Parking Lots		0.0%		0.0%		0.0%
		Other Impervious Area		0.0%		0.0%		0.0%
		Road		0.0%		0.0%		0.0%
		Sidewalk		0.0%		0.0%		0.0%
Stormwater Management		Pond/Open Water Surface Area		0.0%		0.0%		0.0%
		Green Roof		0.0%		0.0%		0.0%
		Porous Pavement		0.0%		0.0%		0.0%
		All Other Pervious Structural BMP Area		0.0%	12,300	1.4%	30,600	3.5%
		Site Totals:	871,200	100.0%	871,200	100.0%	871,200	100.0%
		Check Land Use Totals:	Equals Site Area		Equals Site Area		Equals Site Area	
		Percent Impervious Cover	0.00%		19.46%		15.54%	

Next, the user modifies the area distribution on the **DAs** worksheet:

Land Cover Group		Land Cover Class	Proposed Site Area (ft2)	Unassinged Area (ft2)	DA1	DA2
Pervious		Agriculture	0	0		
		Pasture (with livestock)	0	0		
		Wetlands	0	0		
		Grassland / Meadow / Savannah	0	0		
		Forest / Woods	220,000	0	136,400	83,600
		Lawn / Landscaping	485,210	0	217,990	267,220
Impervious	Residential, Office, Institutional	Rooftops	50,000	0	20,000	30,000
		Driveways & Parking Lots	22,000	0	8,800	13,200
		Other Impervious Area	8,000	0	3,200	4,800
		Road	45,840	0		45,840
		Sidewalk	9,550	0		9,550
	Commercial & Heavy Industrial	Rooftops	0	0		
		Parking Lots	0	0		
		Other Impervious Area	0	0		
		Road	0	0		
		Sidewalk	0	0		
Stormwater Management		Pond/Open Water Surface Area	0	0		
		Green Roof	0	0		
		Porous Pavement	0	0		
		All Other Pervious Structural BMP Area	30,600	0	12,300	18,300
Total Area			871,200	0	398,690	472,510

Proposed Drainage Area (DA) assignments match Proposed Land Use.

The user now selects the appropriate BMPs. The runoff from DA2 is treated by both bioswales and the extended dry detention basin, while the runoff from DA1 is treated by the extended dry detention basin only.

BMPs	DA1	DA2
Extended Wet Detention	☐	☐
Extended Dry Detention	☑	☑
Infiltration Basin	☐	☐
Bioretention	☐	☐
Sand Filter	☐	☐
Infiltration Trench	☐	☐
Vegetated Swale	☐	☐
Bioswale	☐	☑
Vegetated Filter Strip	☐	☐
Dry Well	☐	☐
Rain Barrels	☐	☐
Cistern	☐	☐
Hydrodynamic Device	☐	☐
Catch Basin with Sump	☐	☐
User-defined BMP	☐	☐
Green Roof	N/A	N/A
Porous Pavement	N/A	N/A

The new removal efficiencies are:

Net Reductions for each DA	DA1	DA2
Annual runoff converted to Infiltration + ET	15.0%	44.8%
Total Nitrogen	24.0%	81.8%
Total Phosphorus	20.0%	56.8%
TSS	49.0%	93.4%
E coli	88.0%	88.0%
Copper	29.0%	85.1%

The site now qualifies for three credits:

- Credit 1, Impervious Surface Reduction
- Credit 5, Open Drainage Swale
- Credit 6, Conservation of Natural Areas

No area is entered for the Impervious Surface Reduction Credit, since it is accounted for directly in the Post-Credit column on the **Land Use** worksheet. Part of the forested area (in purple) could qualify for both the Open Drainage Swale Credit and the Conservation of Natural Areas Credit; however, any given area can qualify for only one Stormwater Credit. Therefore, the entire forest area is entered for Credit 6, Conservation of Natural Areas. The remaining area treated by the bioswales is entered under Credit 5, Open Drainage Swale. The rest of the site area is entered in the No Credit column.

Land Cover Group		Land Cover Class	Proposed Site Area (ft2)	Unassinged Area (ft2)		Impervious Cover Reduction	Redevelopment	Water Buffer / Filter Strip	Environmentally Sensitive Development	Open Drainage Swale	Conservation of Natural Areas	Reforestation	Afforestation	Impervious Surface Disconnection	Permeable Pavers	Soils Preservation	Green Rooftop
					No Credit	Credit 1	Credit 2	Credit 3	Credit 4	Credit 5	Credit 6	Credit 7a	Credit 7b	Credit 8	Credit 9	Credit 10	Credit 11
Pervious		Agriculture	0	0		Calculated Automatically											
		Pasture (with livestock)	0	0													
		Wetlands	0	0													
		Grassland / Meadow / Savannah	0	0													
		Forest / Woods	220,000	0							220,000						
		Lawn / Landscaping	485,210	0	217,990					267,220							
Impervious	Residential, Office, Institutional	Rooftops	50,000	0	20,000					30,000							
		Driveways & Parking Lots	22,000	0	8,800					13,200							
		Other Impervious Area	8,000	0	3,200					4,800							
		Road	45,840	0						45,840							
		Sidewalk	9,550	0						9,550							
	Commercial & Heavy Industrial	Rooftops	0	0													
		Parking Lots	0	0													
		Other Impervious Area	0	0													
		Road	0	0													
		Sidewalk	0	0													
Stormwater Management		Pond/Open Water Surface Area	0	0													
		Green Roof	0	0													
		Porous Pavement	0	0													
		All Other Pervious Structural BMP Area	30,600	0	12,300					18,300							
Total Assigned Area			871,200	0	262,290		0	0	0	388,910	220,000	0	0	0	0	0	0
Total area matches																	

The only change in the entry boxes below the **Credits** worksheet land area grid is for the Tc entry. Both the Pre-Credit and Post-Credit Tc are now required. The Tc has not changed enough to exceed the minimum 20 minutes specified by Macomb County for single-family residential development.

Channel Protection Volume required input - Enter Tc values (minutes)

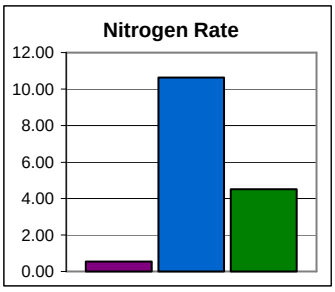
Pre-credit Time of Concentration (Tc, minutes)	20
Post-credit Time of Concentration (Tc, minutes)	20

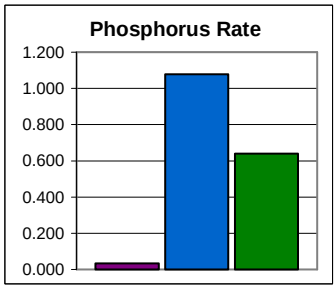
The combination of practices has resulted in a site that has a significantly improved pollutant removal performance.

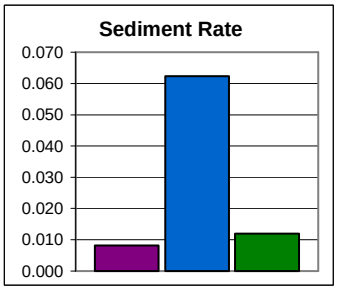
Annual Pollutant Load and Loading Rates (Entire Site)

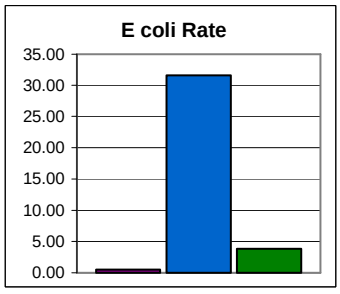
Annual Surface Loads	Existing Landuse	Post-Credit without BMPs	Post-Credit with BMPs
Total Nitrogen (lb/yr)	11	213	90
Total Phosphorus (lb/yr)	0.7	21.6	12.8
Sediment (ton/yr)	0.162	1.247	0.240
E coli (# x 10^9/yr)	10	632	76
Copper (lb/yr)	0.021	0.824	0.242

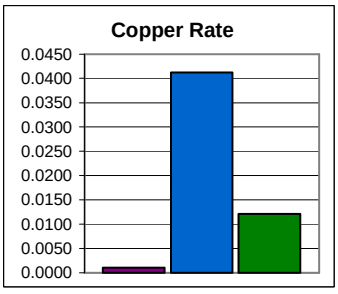
Annual Surface Loading Rates	Existing Landuse	Post-Credit without BMPs	Post-Credit with BMPs
Total Nitrogen (lb/ac/yr)	0.55	10.65	4.51
Total Phosphorus (lb/ac/yr)	0.035	1.079	0.640
Sediment (ton/ac/yr)	0.008	0.062	0.012
E coli (# x 10^9/ac/yr)	0.48	31.62	3.79
Copper (lb/ac/yr)	0.0011	0.0412	0.0121





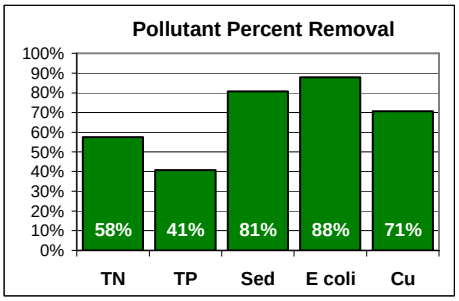






BMP Performance Summary

Pollutant	Post-Credit without BMPs	Post-Credit with BMPs	% Removal
Total Nitrogen (lb/yr)	213	90	57.6%
Total Phos. (lb/yr)	21.6	12.8	40.7%
Sediment (ton/yr)	1.247	0.240	80.8%
E coli (# x 10^9/yr)	632	76	88.0%
Copper (lb/yr)	0.824	0.242	70.6%



Implementation of the Stormwater Credits has resulted in a sizable CPv reduction, from 42,684 ft^3 to 37,717 ft^3.

Stormwater Credits Summary

	Pre-Credit	Post-Credit	
Water Quality Volume (ft^3)	Not Required	Not Required	Extended detention provided for site
Channel Protection Volume (ft^3)	42,684	37,717	

5 BMP Toolbox

Structural BMPs are practices that require construction, installation, and maintenance. The types of practices appropriate for a given area will depend on several factors including physical site constraints, maintenance requirements, administrative resources, and cost. The following list describes commonly used structural BMPs.

Extended Wet Detention

An extended wet detention pond maintains a permanent pool of water. This device stores stormwater runoff and reduces stormwater flow. The ponding of stormwater allows excess sediment to settle out of the water and encourages bacteria and algae to use excess nutrients. Shoreline plants and other aquatic vegetation may also remove nutrients. Portions of other pollutants may also be removed. Under typical designs, stormwater first enters a forebay, which is a small depression lined with rocks that slows the incoming stormwater flow and settles out larger particles. The outlet structure and emergency spillway control the rate of water draining out of the pond.

Extended Dry Detention

Extended dry detention basins are typically grass-lined basins that are dry between storm events. These devices store stormwater runoff and reduce stormwater peak flow rates. Stormwater enters the device through an inlet, which may be a grass-lined channel or stormwater pipe. An embankment detains stormwater, and an outlet riser controls the downstream release rate of the impounded water. Stormwater is detained for a longer period of time than in conventional dry detention basins (between one to three days); the longer detention time allows for more removal of TSS and nutrients from the stormwater.

Infiltration Basin

An infiltration basin is similar to a dry detention basin, but is designed to completely infiltrate its storage volume, typically the runoff from a water quality volume storm (around one inch). The underlying soils must be permeable enough to allow the volume to infiltrate within a few days. During construction, care should be taken to limit or prevent compaction of the basin's infiltration surface. Infiltration basins frequently have a larger surface area than other BMPs to allow enough contact area for infiltration. Pollutant removal is generally excellent, since most of the runoff does not leave the site. In many locations, an outlet structure must be added to convey larger storm events, and can be used effectively for peak flow control for smaller design storms.

Bioretention

Bioretention areas are depressions filled with 2 to 4 feet of sandy soil and planted with drought and flood tolerant plants. Stormwater drains into the surface of the bioretention area and, as the water infiltrates through the sandy soil, the soil and plants remove a portion of pollutants. In areas with sandy loam or other highly permeable soils, the water treated by the bioretention cell will infiltrate into the native soil. In areas that have soils with low permeability (typically clay-dominated soils), a gravel layer and underdrain pipe are placed below the sandy soil layer. Once the stormwater infiltrates through the treatment cell's sandy soil, it is drained out of the device through the underdrain pipe. Bioretention areas are designed so that a particular depth of water can pond in the cell during a rain event; the storage depth varies from 6 to 12 inches depending on local design standards. Sometimes a weir is included in the bioretention area to bypass excess water above the ponding depth; other installations allow excess water to filter onto adjacent pervious areas. Since bioretention areas use mulch and a variety of shrubs and small trees, they can be easily incorporated into existing landscaping.

Sand Filter

A sand filter is typically constructed as a two-chambered structure in which water first flows into an empty sedimentation chamber. As the chamber fills with water, the sediment suspended in the water settles into the bottom of the chamber. The water then flows into a sand-filled chamber, and as the water infiltrates through the sand, a portion of the pollutants is removed. Sand filters can be easily incorporated into parking lots and space-restricted locations, as shown to the right, but do require frequent inspection and maintenance.

Infiltration Trench

An infiltration trench is a concrete chamber or ditch filled with crushed rock. An infiltration trench fills with stormwater runoff and allows the water to infiltrate into the soil, providing a net reduction in surface runoff and stormwater pollutants.

Vegetated Swale

A vegetated swale is a grass-lined channel with sloped banks. Culverts are used to pass stormwater under driveways and streets. Vegetated swales are used to convey stormwater runoff and slow stormwater flow. They are an alternative to storm sewer pipes, which produce higher stormwater flows than vegetated swales, especially for smaller storm events. Vegetated swales also remove some sediment if the stormwater flow is controlled.

Bioswale

A bioswale is a channel designed to control stormwater flow and encourage infiltration and removal of pollutants. Similar to a bioretention cell, a bed of sandy soil is installed in the channel and planted. A gravel underdrain can be installed below the sandy soil if the native soil does not allow for sufficient infiltration. Small structures called check dams may be used to control water flow. Larger flows are allowed to bypass the swale.

Vegetated Filter Strip

A vegetated filter strip is a flat strip of land planted with grass or other vegetation. Level spreaders are frequently used with vegetated filter strips to distribute stormwater runoff and releases the water as sheet flow onto the filter strip. When combined, these two devices reduce stormwater flow and remove a portion of sediment and pollutants from stormwater runoff.

Dry Well

A dry well, also called a French drain, seepage pit, or Dutch drain, is a gravel-filled pit or trench designed primarily to capture and infiltrate roof runoff, usually by directing the downspout into the well. Dry wells have been used for decades to solve drainage problems, but are also a practical stormwater BMP. Design recommendations call for locating dry wells a safe distance away from the building, ensuring they are separated from the water table and that soils support infiltration, and providing a way to safely pass large storms. While rooftops usually have lower pollutant loads than other impervious surfaces, dry wells do effectively store and treat a significant volume of runoff.

Cisterns/Rain Barrels

Cisterns are tanks that hold rainwater for irrigation and other uses. The cistern pictured to the right can hold over 200 cubic feet of water. These BMPs can be pre-manufactured or constructed on-site. They also can be incorporated inconspicuously into the side of a building. Rain barrels typically hold less water than cisterns, about 8 cubic feet per rain barrel. If enough storage volume is provided and if water is reused frequently, they can be used to control stormwater runoff, reduce stormwater flow, and remove pollutants by preventing them from entering runoff.

Hydrodynamic Device

Also called manufactured water quality devices, manufactured stormwater treatment systems, and swirl interceptors, these devices are placed underground and are designed to receive runoff from the stormwater conveyance system and remove particle pollutants, oils, and floatables. There are many variations in design, but most use a combination of settling chambers and hydrodynamic separation (causing water to spin in a circular chamber to concentrate solids in the center). Most are manufactured by specialty companies. These devices are highly effective at trapping oil and trash, and removing coarser sediments like sand, but have limited effectiveness for removing silt and clay. Frequent maintenance and cleaning out of accumulated sediment is critical for their continued performance.

Green Roof

Green roofs are grassy areas or gardens installed on a roof. Rainfall infiltrates into the soil of a green roof, and a net reduction of stormwater runoff is achieved as the plants and soil media facilitate the evaporation of collected rainfall. Green roofs vary in design depending on the type of vegetation and how the roof will be used. Extensive green roofs are simple, low maintenance designs that do not allow public access to the roof. Intensive green roofs allow safe, public access to the roof and tend to have more elaborate, higher maintenance gardens than extensive green roofs.

Porous Pavement

Porous pavement differs from conventional asphalt and concrete in that it allows for infiltration of water during a rainfall event. Porous pavement types include porous asphalt, porous concrete (shown to the right), and paving stones interspersed with sandy soil or other porous fill. These types of pavement vary in vehicular traffic capacity. Grass parking lots, reinforced with plastic rings, are typically used for overflow parking, while some permeable pavement can be designed to handle more frequent traffic.

Catch Basin with Sump

This BMP is already commonly used in Macomb County. Its primary function is for capturing trash and debris, but is also somewhat effective for capturing sand particles, depending on design. To be effective, the sump must be emptied on a regular, frequent basis. The maintenance interval may vary depending on the characteristics of the contributing drainage area (for instance, use of road sand may fill a basin more quickly). Studies have shown that catch basins may become ineffective when the sump reaches 60% of its capacity; large storms flush out additional trapped sediment. Another study determined that the greatest amount of sediment reduction could be achieved with monthly cleanout of sumps (three to five cubic feet); less frequent intervals (quarterly through annual) reduced the sediment recovered by a large margin (0.8 to 2.5 cubic feet)[6].

Photographs from the following sources: Bioretention – Mecklenburg County, NC; Cistern/Rain Barrels – Clemson University; Conventional Dry Detention and Extended Dry Detention – Tetra Tech, Inc.; Vegetated Swale – U.S. EPA; Green Roof – U.S. General Services Administration; Infiltration Trench – Caltrans, Division of Environmental Analysis; Water Quality Swale – Prince George's County, MD; Porous Pavement – Greg McKinnon, Pudget Sound Online; Sand Filter – NC State University; Vegetated Filter Strip and Level Spreader – Caltrans, Division of Environmental Analysis; Extended Wet Detention – Tetra Tech, Inc.; Hydrodynamic Device – NC State University Biological and Agricultural Engineering, Bill Hunt PE PhD.

[6] Mineart, P., and S. Singh. 2000. *The Value of More Frequent Cleanouts of Storm Drain Inlets*. In: The Practice of Watershed Protection, editors T. Schueler and H. Holland. Center for Watershed Protection, Ellicott City, MD.

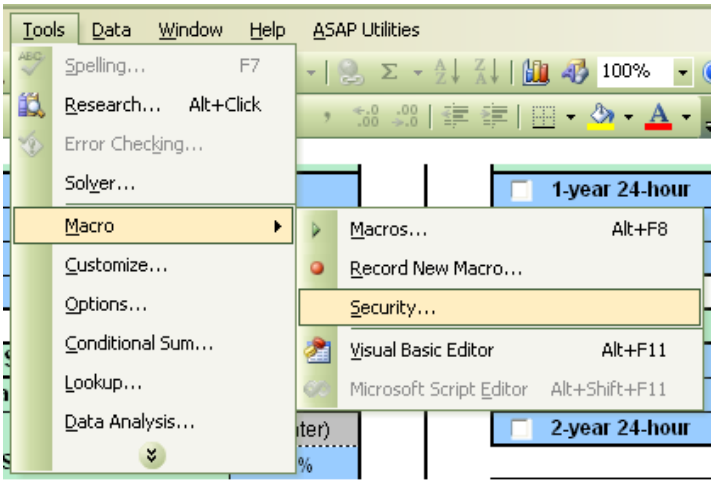
Appendix A. Macro Security in the SET

The SET makes extensive use of Microsoft Visual Basic for Applications (VBA) script, both for navigation and for more complicated internal calculations. The use of these "macros" is essential to the SET. However, macros are also a potential vehicle for malicious code, and there are a number of settings built into Excel that allow the user to tailor the level of security.

One of these settings (frequently enabled by default in Excel) prevents all macros from running, and also may not warn the user that macros are disabled. In the case of the SET, the user cannot proceed past the initial input screen.

The following instructions apply to Excel 2000, Excel XP, and Excel 2003. Excel 2007 users can find similar settings under the Developer tab, in the Code group, by clicking on the Macro Security button. You may need to enable the Developer tab first.

To enable the SET to use its VBA Script, please make the following changes to your Excel security settings. On the menu, select **Tools**, choose **Macro**, and then choose **Security…** In the window that opens, select the **Security Level** tab.



Select the button next to **Medium**, and click the **OK** button. Now when you open the SET, you should be given a choice to enable macros. You must enable macros for the SET to operate properly.

The **Security Level** will remain set to **Medium** even after you close the SET – this setting applies to Excel as a whole, not just the SET. You may change the **Security Level** to a higher setting after you have finished using the SET, but you would need to reset it to **Medium** whenever you use the SET.